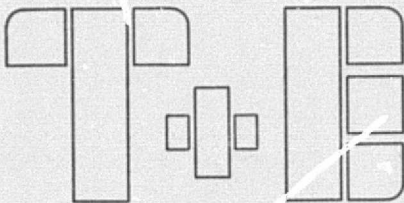


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129 Mount Auburn Street  
Cambridge, Massachusetts 02138  
617 491-1500

Submitted to:

URBAN SYSTEMS PROJECT OFFICE

Johnson Space Flight Center  
NASA  
Houston, Texas

URBAN CONSTRUCTION AND  
SAFETY PROJECT

Final Report

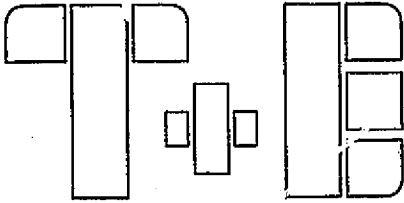
February, 1976

Contract # NAS9-14529



Principal Author:

Peter T. Hogarth



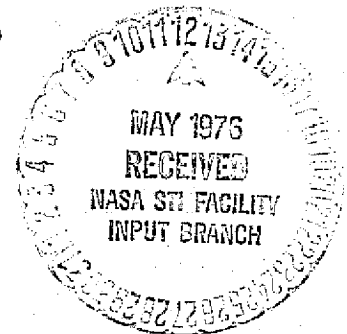
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URBAN CONSTRUCTION AND  
SAFETY PROJECT

Final Report  
February, 1976

Contract # NAS9-14529



Principal Author;

Peter T. Hogarth

## PREFACE

This report summarizes the activities of the 1975 Urban Construction and Safety Project at Technology + Economics, Inc., for the period of February 10, 1975 through February 10, 1976.

The objective of the project is to apply technology developed by the National Aeronautics and Space Administration (NASA) to problems identified in urban construction and safety. The project is supported by the NASA Technology Utilization Office and monitored by the Urban Systems Project Office of Johnson Space Center under contract NAS9-14529.

NASA Staff involved in the project were as follows:

Carely Lively, Contract Manager.

William L. Smith, Technology Applications Division.

Andrew Sears, of the Technology Application Division, served as principle government technical advisor.

James Hankins of Marshall Space Flight Center, served as technical advisor on matters related to the flat conductor cable project.

Technology + Economics contract staff was as follows:

David J. MacFadyen, Project Director

Allan D. Ackerman, Operations Manager

James R. Simpson, Senior Scientist

Peter T. Hogarth, Analyst

Robert F. Stone, Economist

Alexis Anderson, Documentation

Margaret M. Bucciero, Secretary

## INTRODUCTION

This report contains four main sections plus an appendix. Section 1.0 is a background description of the general nature of the technology transfer activities that the Urban Construction and Safety Project engages in. Section 2.0 provides an overview of the highlights of this year's project activity. Section 3.0 is a more detailed description of these activities. Section 4.0 is a concluding statement that describes certain insights that we have derived this year concerning technology transfer in the context of the NASA Technology Utilization Program. The appendix contains several important documents produced by the year's activity.

## TABLE OF CONTENTS

Page no.

1.0	THE TECHNOLOGY TRANSFER PROCESS.....	1
2.0	OVERVIEW OF THE 1975 PROJECT.....	6
3.0	DETAILED PROJECT ACTIVITY.....	8
3.1	<u>Flat Conductor Cable</u> .....	9
3.1.1	<u>Background and Summary</u> .....	9
3.1.2	<u>Undercarpet FCC Implementation Project: Chronology</u> .....	14
3.1.3	<u>Baseboard FCC Implementation Project: Chronology</u> .....	31
3.2	<u>Flood Insurance Studies</u> .....	35
3.3	<u>Tornado Studies</u> .....	42
3.4	<u>The "Project Tech" House</u> .....	44
3.5	<u>Assistance to the City of Atlanta</u> .....	45
3.6	<u>Diesel Engine Controller</u> .....	45
3.7	<u>Mobile Home Testing</u> .....	46
4.0	CONCLUSION.....	48
4.1	<u>Leverage</u> .....	48
4.2	<u>Tech Search and Access</u> .....	50
5.0	APPENDIX.....	53
5.1	<u>Flat Conductor Cable: Selected Papers and Materials</u> .....	54
5.2	<u>Flood Insurance: Selected Papers and Materials</u> .....	78

## LIST OF FIGURES

<u>Figure</u>	<u>Page No.</u>
The Tech Transfer Process: Problems in Search of Solutions.....	3
The Tech Transfer Process: Development of Tech- nologies with Commercial Potential.....	4
FCC Undercarpet System Project: Applications Process.....	13
Undercarpet System: Hardware/Money/Paperwork Contributions to UL and NEC Efforts.....	22

## 1.0 THE TECHNOLOGY TRANSFER PROCESS

"Technology transfer" is the application of products or techniques developed for special purposes in one context to needs or opportunities perceived in another. It takes a need or opportunity from one context and matches it with a relevant technology developed in another context. This process can occur spontaneously, or it can be deliberately and systematically hastened.

NASA's Technology Utilization Program works deliberately and actively towards the full technology utilization promised in the National Aeronautics and Space Act of 1958:

The aeronautical and space activities of the United States shall be conducted so as to contribute...to the expansion of human knowledge of phenomena in the atmosphere and space. The Administration shall provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

An important component of NASA's program to meet this mandate has been the establishment of Technology Application Teams (TAT's) designed to actively match problems in specific applications areas with NASA solution technologies. The Urban Construction and Safety Project (USCP) at Technology + Economics, Inc., (T+E) is one such team.

Technology transfer is never a cut-and-dried process that proceeds according to a set pattern. The constraints and opportunities presented by each transfer project are unique, and define their own appropriate operational style. Nevertheless, in every completed transfer project, there are certain basic logical elements that always occur and that can be identified in some form. These basic elements are the following:

- An identifiable and definable problem in the applications sector.
- An identifiable potential solution technology within the body of NASA technological resources.



- An ongoing assessment of the feasibility of the proposed problem/technology match, and of ways to improve this match.
- A user -- governmental, institutional, or commercial -- who can specify exactly the performance and cost requirements of the solution technology and who can motivate the needed applications process.

Although they are not logically inherent to the process, the following elements are also generally present:

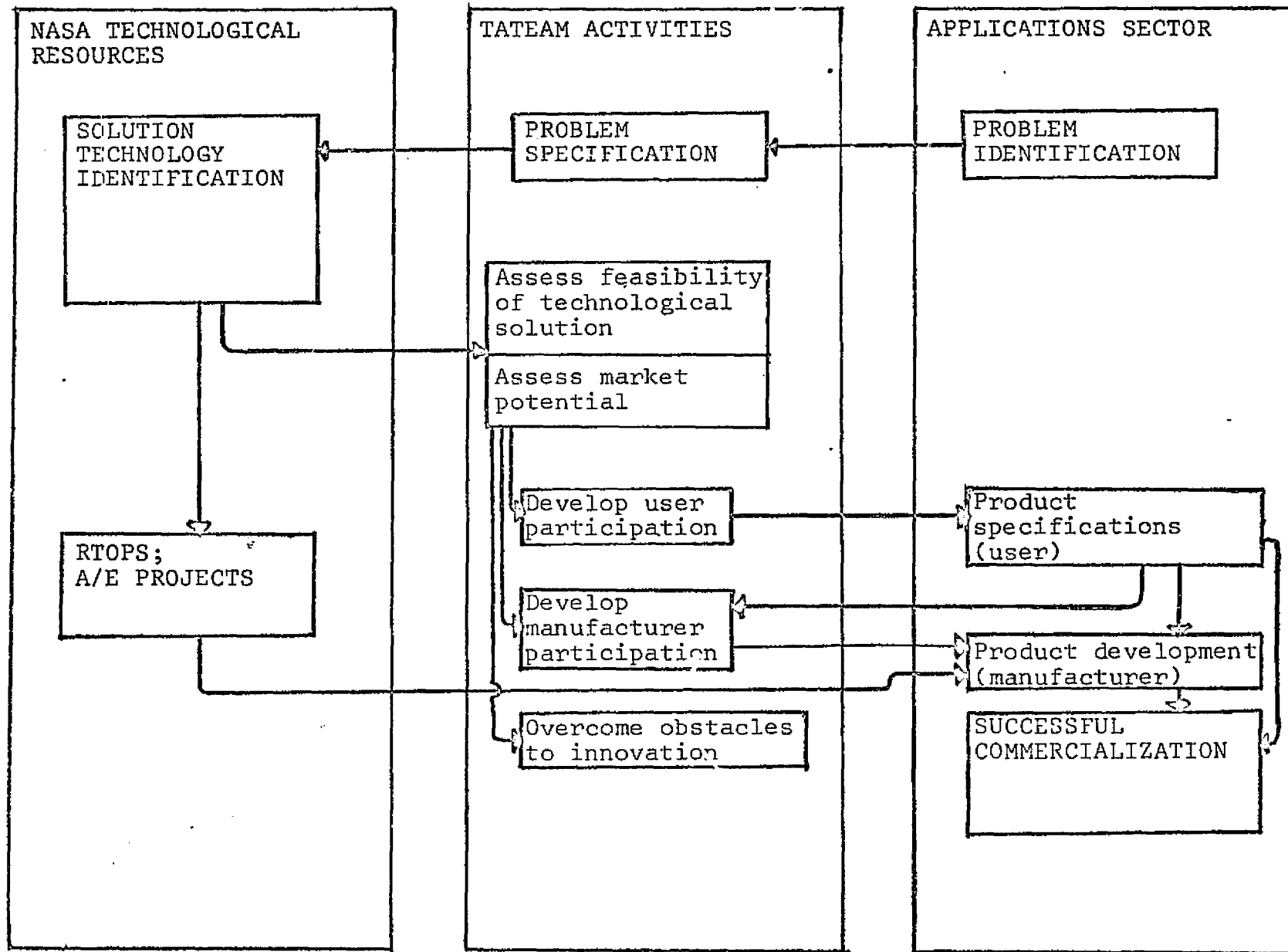
- An applications process involving developmental work on the part of NASA, users, and/or private manufacturers to transform the "raw" technology into a form appropriate for the new application.
- Ongoing implementation management on the part of the TAT to facilitate communication between the various interest groups and to overcome the obstacles to the innovation that may develop.

These elements interact in a complex and varied pattern. Sometimes different parts of the process occur simultaneously; sometimes sequentially; and sometimes iteratively. An iterative process is frequent: initial work toward implementation of an identified problem-technology match often requires the UCSP team to re-define the problem and subsequently consider alternative technologies.

The most significant type of variation between different transfer activities lies in the direction of the impetus to transfer. This direction determines the basic structure of the transfer process. A fundamental dichotomy may be identified between tech transfer in which a known problem exists for which a technological solution is sought; and in which a promising technology exists for which an application is sought. These two processes may be termed respectively "market pull" and "tech push". An example of a "market pull" process from current UCSP work is the problem of the high cost of flood insurance studies for which a NASA-developed solution is being sought; an example of a "tech push" project is a diesel engine controller developed at Johnson Space Flight Center for which the UCSP is assessing the market potential. The accompanying two charts respectively schematize the characteristic forms of "market pull" and "tech push" transfer processes.

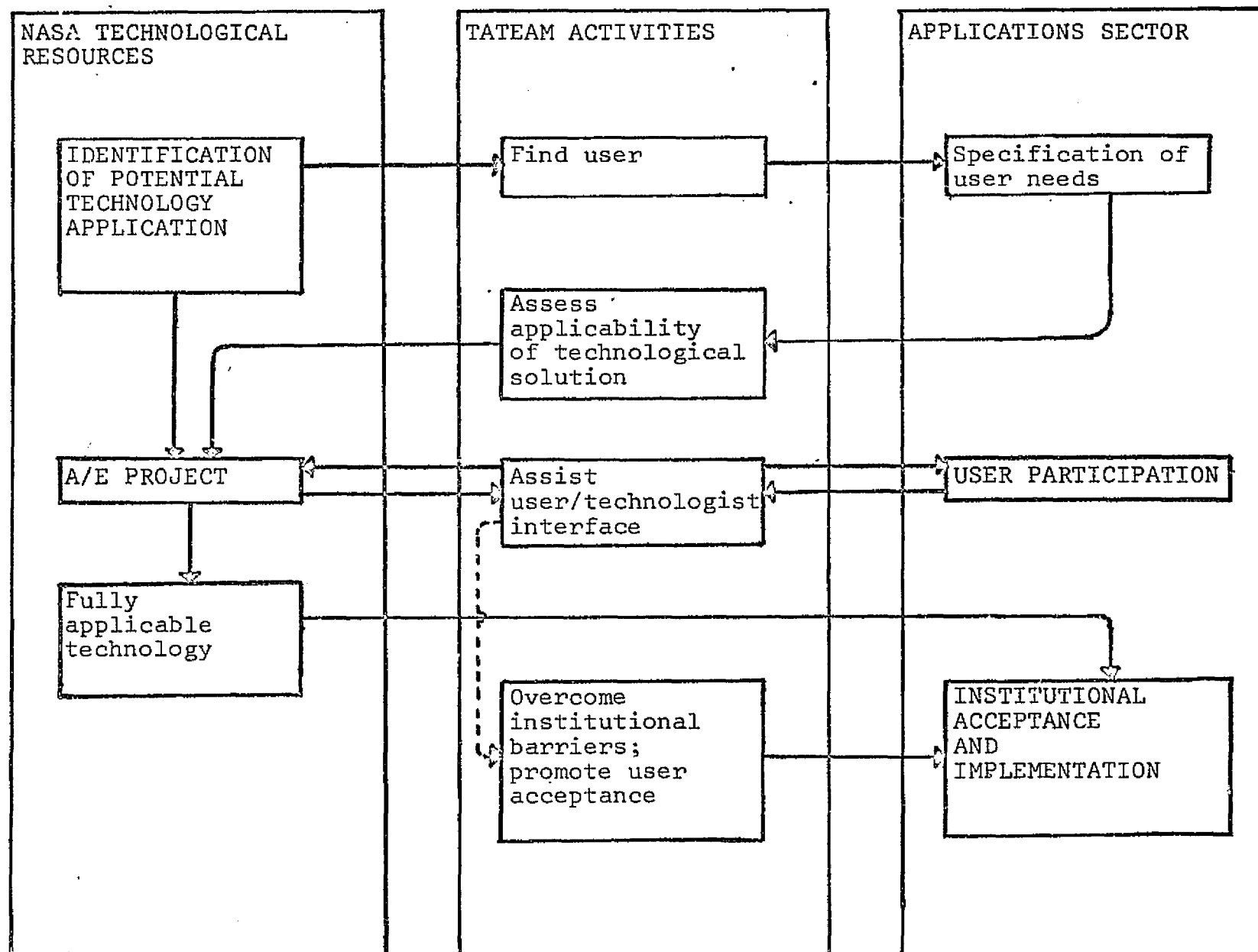
# THE TECH TRANSFER PROCESS

## I. PROBLEMS IN SEARCH OF SOLUTIONS...



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## II. DEVELOPMENT OF TECHNOLOGIES WITH COMMERCIAL POTENTIAL:



It will be seen that the basic elements of each process are similar. What is different is the direction of flow of the process which engages these elements; the difference is symbolized by the reversal of the direction of many of the arrows.

This brief overview of the technology transfer process as it has been pursued by the T+E UCSP is highly abstract. The next section of the report will present the UCSP team activities from a more operational point of view. It will show some ways in which the abstract process called "technology transfer" actually occurs, and indicate what the present project is achieving.

## 2.0 OVERVIEW OF THE 1975 PROJECT

The Urban Construction and Safety Project carried out a number of significant technology transfer projects in 1975. They include:

- Projects to commercialize undercarpet and baseboard Flat Conductor Cable systems.
- A project to implement NASA assistance for the flood insurance studies of the Federal Insurance Administration.
- Implementation of NASA-sponsored research on the tornado safety of critical buildings.
- Ongoing assistance in design and in selection of technologies for the "Project TECH" house at Langley Research Center.
- Assistance to the City of Atlanta in applying NASA technology to their environmental habitability and resource allocation problems.
- Market assessment for a NASA-developed, solid-state diesel engine controller.

Of these projects, the first two -- Flat Conductor Cable and flood insurance studies -- are particularly important and promising.

The undercarpet Flat Conductor Cable has resulted in an ongoing development and commercialization effort heading headed by T+E and involving ten manufacturers and users of electrical and related equipment. It is expected that commercialization of the undercarpet system will have major impact on office and commercial electrification.

The flood insurance study project has revealed that NASA technologies have great promise in cutting the costs of these studies, and in increasing the effectiveness of the Federal Insurance Administration's work. T+E is now in the final phases of arranging an interagency transfer of funds to Jet Propulsion Laboratories for selected feasibility studies.

All these projects are discussed in detail on the following pages.

### 3.0 DETAILED PROJECT ACTIVITY

This section describes in detail the activities of the T+E Urban Construction and Safety Project in the project areas listed in the previous section. Section 3.0 is organized as follows:

#### 3.1 Flat Conductor Cable (FCC)

##### 3.1.1 Background and Summary

##### 3.1.2 Undercarpet FCC Implementation Project; Chronology

##### 3.1.3 Baseboard FCC Implementation Project; Chronology

#### 3.2 Flood Insurance Studies

#### 3.3 Tornado Studies

#### 3.4 The "Project TECH" House

#### 3.5 Assistance to the City of Atlanta

#### 3.6 Diesel Engine Controller

#### 3.7 Mobile Home Testing

### 3.1 Flat Conductor Cable (FCC)

#### 3.1.1 Background and Summary

The major implementation project of T+E's 1975 Urban Construction and Safety Project was the application of Flat Conductor Cable to building wiring. Flat Conductor Cable, or FCC, is a thin profile cable originally developed for aerospace applications. When applied to building wiring, it permits very low profile electrical systems that can be surface mounted on walls, floors, and ceilings. FCC systems are intended to achieve major breakthroughs in the cost and system flexibility of building wiring.

Two separate systems are being developed: an undercarpet system and a baseboard system. The undercarpet system employs a flat power cable, protected by a grounded metal shield, that terminates in floor-mounted receptacles. It is designed to interface with a flat-conductor cable telephone system engineered by Western Electric. The advantages of the undercarpet FCC system lie in its elimination of expensive underfloor ductwork in new buildings, and in vastly simplified system revision in existing buildings. The baseboard system involves a flat power cable mounted in a plastic surface-mounted baseboard raceway with baseboard-mounted receptacles. It also has provision for foil-protected wall and ceiling-surface runs. It has strong cost-saving potential for renovation work and for concrete and masonry construction.



T+E's 1975 FCC activity was the result of several years of effort to find and mobilize manufacturers and potential system users interested in commercializing the systems. This year, the undercarpet and baseboard FCC were pursued as two independent projects.

The undercarpet project took the form of a major effort involving ten manufacturers and system users. T+E's role in the undercarpet project passed from an initial advocacy role to a complex implementation management task involving the technical coordination of the ten private organizations plus NASA. The project moved forward rapidly, largely on the strength of the interest shown by two large users--Western Electric and the General Services Administration.

The undercarpet project focused upon obtaining approval of the National Electrical Code (NEC) for the system. The current NEC does not allow FCC-type systems; a new Code article will be required. T+E and the industry group developed a proposed new article and submitted it to the NEC committee in December. Final action on the proposal will come in December of 1976. There is good cause for optimism that the proposal will be approved and the undercarpet system will be permitted by the 1978 Code.

As part of the Code-change effort, a fact-finding study was undertaken at Underwriters' Laboratories (UL) at Melville, Long Island. The study was sponsored by T+E and supported jointly by NASA and the industry group. It serves as a background

of test data and analysis that will aid the NEC panel in assessing the safety and durability of the system. An Interim Report containing most of UL's findings was submitted to the Code panel in December along with the Code change proposal. UL's final report will be completed in mid-1976.

Thanks to the 1975 implementation project, the need for major NASA involvement in the undercarpet system is drawing to a close. Industry is increasingly taking the lead in the approvals and commercialization process. While the effort with the NEC and UL is by no means complete, most of the needed work has by now been performed. Other issues, however, are coming to the forefront that will need attention. They include the following:

- If the 1978 NEC permits FCC systems, it will still be necessary to facilitate acceptance by local and city codes, and by local electrical inspectors.
- The UL Fact-Finding Study addresses viability of the system from a conceptual point of view. It will still remain to obtain approval by UL of individual system components. It will be the responsibility of the individual manufacturers to obtain the approvals.
- Electricians' unions will have to accept FCC systems before they can be installed on a widespread basis. At issue will be the impact of FCC on electricians' work time (T+E has authored a study that addresses this issue).

A reduced but continuing NASA/TATeam involvement in the remaining phases of the undercarpet project will expedite full commercialization and ensure that the final system configuration is optimal.

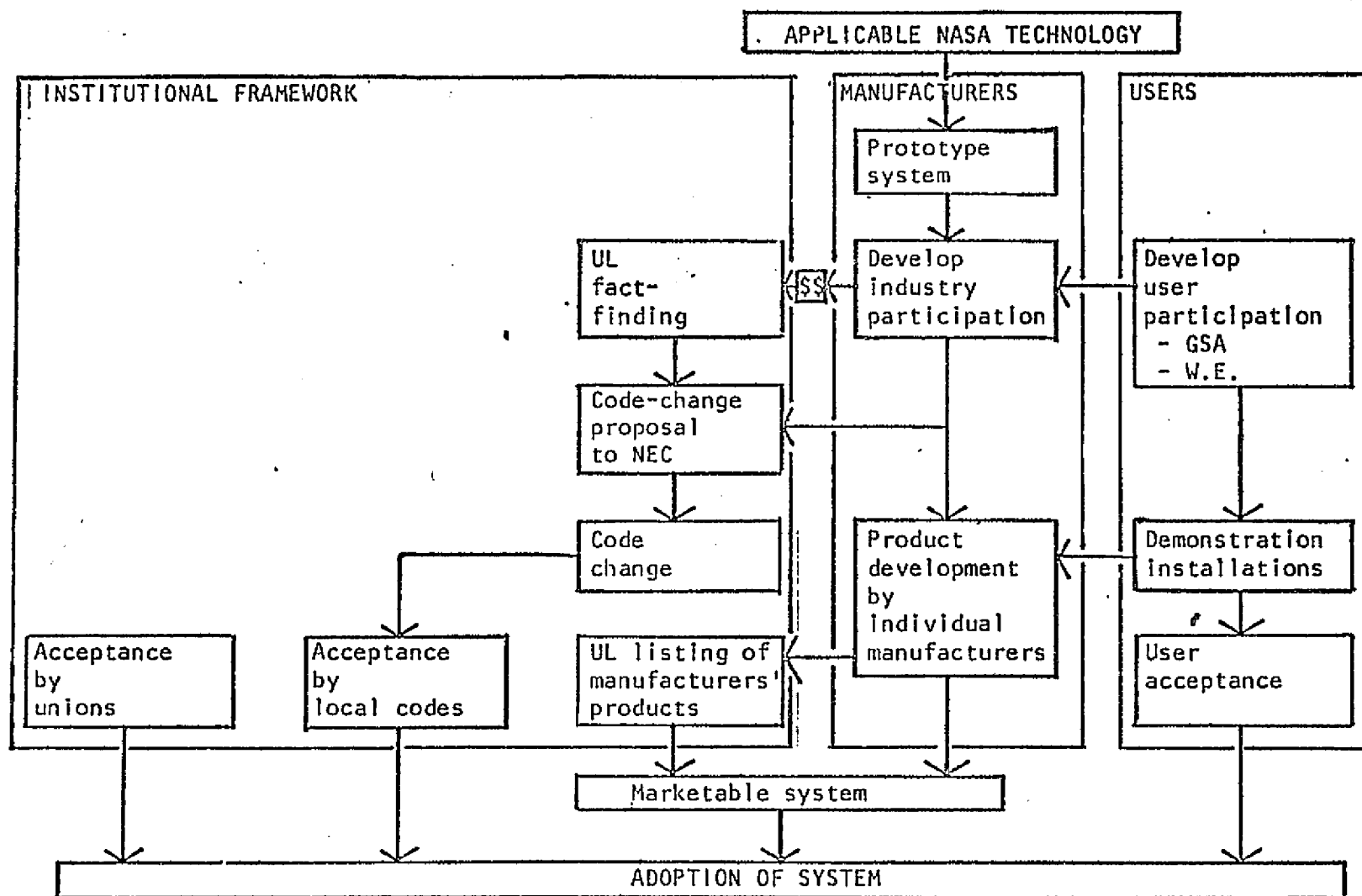
The accompanying chart shows the major steps involved in carrying out the FCC implementation projects.

T+E also undertook in 1975 a baseboard FCC implementation project in parallel with the undercarpet project. The baseboard effort, however, was pursued at a lower level of effort, and is currently at a less advanced stage than the undercarpet project. Although T+E has continued to advocate the baseboard system to users and to industry, manufacturers have not yet shown a comparable degree of interest in it, and as yet no organizations are firmly committed to commercializing it.

Technical development has nonetheless proceeded for the baseboard system, at Marshall Space Flight Center. A prototype system is available for testing and product development. T+E and NASA commissioned a preliminary fact-finding study for the system at UL. This study indicated that from the industry point of view technical modifications of the system were still needed. Although a Code-change proposal for the baseboard system had been planned, none was submitted in the end, because of the additional work needed. Marshall Space Flight Center plans to complete the necessary modifications this spring.

The next two sections of the report deal, respectively, with the undercarpet and baseboard FCC projects, and describe T+E's implementation activities in detail.

# FCC UNDERCARPET SYSTEM PROJECT -- APPLICATIONS PROCESS



### 3.1.2 Undercarpet FCC Implementation Project:

#### Chronology

##### First Quarter: February-April

Prior to the formal start of the 1975 project in February, T+E pursued FCC-related activities as needed for the sake of continuity of the FCC effort. One such activity was assistance to help NASA conduct an FCC exhibit at the Industrialized Building Exposition (INBEX) in December, 1974. T+E and NASA personnel set up and conducted a three-day exhibit, which resulted in a large amount of contacts from interested industry representatives. Another important activity during this time was assistance to NASA in preparing draft testimony on flat conductor cable for the February 3rd Congressional appropriations hearings. The testimony included results of some new inquiries into possible copper-saving and safety implications of FCC.

The 1975 project formally began in early February. In February and March T+E conducted a comprehensive review of project status and assessed the future needs of the FCC commercialization effort. It was clear that the FCC project had been following a discoordinated course of development in the preceding several months. The problems related to:

- Standardization of cable size.
- The feasibility of a two-wire system incorporating a fail-safe ground fault interruptor.
- Coordination of hardware development by different industry participants.
- Understanding of the process of gaining approval for FCC systems.

It was also clear that additional industry participation in the FCC commercialization process would be very desirable. So far, the strength of the project had rested on the interest of the General Services Administration and of one large private potential user: Western Electric. An additional reason for Western Electric's involvement was their interest in telephone FCC systems installed in conjunction with the undercarpet power system. On the power system manufacturing side there were just two concerns who had been consistently interested in FCC: Parlex Corporation, a small cable manufacturer; and AMP, Incorporated, a somewhat larger hardware manufacturer.

The month of February saw expressions of interest in developing and marketing FCC system components from two more organizations--The Thomas and Betts Company came forward with plans to develop a complete undercarpet system, and possibly to manufacture cable through their Ainsley Division. T+E met with two representatives of Thomas and Betts and discussed their participation in the FCC venture. Hi-Temp Wires expressed interest in manufacturing cable.

During February and early March, T+E worked closely with industry representatives to define what was needed in terms of the future course of the FCC implementation project. By mid-March, its outlines were clear: it would primarily involve development of a proposal to change the National Electrical Code (NEC) to permit FCC systems. A fact-finding study at

Underwriters' Laboratories (UL) would be appropriate, in order to provide background data and analyses for the NEC proposal. A further requirement would be the development of overall system specifications to ensure system safety and component compatibility.

As the month of March progressed, T+E activities shifted more and more from planning to action. Coordination and direction were needed by the many organizations, public and private, interested in FCC. The need was identified for a general meeting of these interested parties to address the major issues and to develop a detailed project plan for the coming months.

In response to this need, two meetings were held in April on the 9th and 24th.

The April 9th meeting was a large general meeting that included participants from NASA, the Department of Housing and Urban Development, the National Bureau of Standards, the General Services Administration, and private industry.

The main issues that were discussed were:

- Ground Fault Circuit Interruption (GFCI) capacitance leakage compensator.
- Cable standardization: metric vs. English.
- Procedure for accomplishing National Electrical Code (NEC) changes.
- Coordination of development efforts.

The conclusions of the meeting were as follows:

- A special GFCI with variable capacitance compensation should be developed. A private sponsor is needed.
- It will be too difficult at this time to develop a fail-safe two-wire system and gain its acceptance.
- Cable should be sized according to the English system--specifically, by AWG sizes.
- Procedure for Accomplishing NEC Changes: The deadline for submission of a proposal for a Code change is December 1, 1975. The customary procedure is to ask UL to perform a fact-finding study in advance of any proposed Code change. It was proposed that the cost be shared by a number of organizations. This approach received general approval.
- Coordination: NASA should provide the technical leadership for the continuing cooperative effort necessary to accomplish the Code change, since no one of the vendors or prospective users could comfortably take such a central role. T+E should provide the mechanism for collecting the monies and arranging the contract with UL; the participating organizations should pay for the UL study through T+E. T+E should also serve in a general coordinating role.

The April 24th meeting was primarily a working session of industry participants to prepare for the meeting with UL to be held in early May. The industry attendees were:

- AMP
- Leviton
- Parlex
- Thomas & Betts
- Western Electric/Bell Labs

Also attending were T+E and Carey Lively of the JSC Urban Systems Project Office.

The meeting dealt almost entirely with the undercarpet system. The following objectives were accomplished:

- Cable dimensions and specifications were provisionally set.
- The dimensions and configurations for the protective cable shield were provisionally set.



- Different receptacle designs were discussed, and a pigtail device was chosen for UL submission.
- Possible locations in the system were discussed for the GFCI/compensator.
- The schedule and mechanics of submissions were again outlined; hardware and financial contributions were provisionally allocated.

These two meetings were enormously useful to all participants. They clarified and began to resolve many of the critical issues surrounding the FCC system. A working group for the implementation project began to take form, and a plan of action was developed.

#### Second Quarter: May-July

In this quarter, the project review, organization, and planning of the previous months gave way to an active implementation phase. By the end of July, an undercarpet system test installation was in place at UL, and UL was beginning their test program.

The month of May marked the initiation of a working relationship with Underwriters' Laboratories (UL) to obtain a fact-finding study on the system. In addition, four new manufacturers became involved in the project.

As a result of the May activity, manufacturers are available to supply all currently needed hardware and materials and a firm groundwork had been laid for the necessary system validation and approval.

The highlights of the month's activity were two meetings with industry participants in the project. On May 7th, a

meeting was held with UL at Melville, Long Island. It was attended by representatives from:

- AMP, Inc.
- Dupont Co.
- Thomas and Betts, Inc.
- UL
- Western Electric
- T+E

This meeting followed the submission through T+E of a formal request to UL for a fact-finding study. The meeting accomplished three primary purposes:

- To introduce the UL personnel to T+E and the industry participants.
- To reach agreement on the system configuration to be tested.
- To clarify the steps required for completing the fact-finding study and submitting a Code change proposal.

UL responded to this meeting with a letter dated May 19th outlining the testing program they saw as appropriate and a detailed list of the materials and hardware required. The cost of the study was set at \$18,000.

During this same time period, a search for additional industry participants continued. Two potential participants in the project (General Electric and Leviton) decided early in May not to participate for the time being. Their loss was balanced, however, by the entrance of four major new participants:

- Brand-Rex Co. (a cable manufacturer)
- Lamotite Products (a foil manufacturer)
- Millikan, Inc. (a carpet manufacturer)
- DuPont (Film Department--for insulating films)

On May 28th, a second meeting of industry participants was held at Newark Airport. The attendees were:

- Brand-Rex
- DuPont Co.
- Lamotite Products
- Paperfilm Associates (an insulation supplier)
- Thomas & Betts, Inc.
- Western Electric
- Technology + Economics, Inc.

The meeting was, in effect, an elaboration of previous meetings: it introduced the new participants to the project and assessed their possible contributions to it. The willingness of Brand-Rex, Lamotite, and DuPont to contribute materials was established. Certain remaining technical questions were addressed; in particular, the final configuration of the protective foil was determined, and Lamotite agreed to fabricate and deliver it.

In June, T+E's main role was to finalize the funding of the UL study, and to coordinate the delivery of hardware to UL. An undercarpet FCC project meeting was held on the 18th and was attended by the following organizations:

- AMP, Inc.
- Brand-Rex Co.
- Collins and Aikman (a carpet manufacturer)
- DuPont
- Lamotite Products
- Parlex Corp.
- Thomas and Betts, Inc.
- Western Electric
- Johnson Space Center-Urban Systems Project Office
- Marshall Space Flight Center
- T+E

One of the companies, Collins and Aikman, was a new participant to the project. The meeting served two purposes: it gave the industry participants an opportunity to present and describe the system hardware to UL; and it allowed UL to further outline their testing program and requirements in light of the companies' hardware descriptions.

On the basis of this meeting, the UL testing program and the participants' responsibilities were finalized for the July 1st hardware submission deadline. The list of financial contributions took shape, although it was not finalized until July. The distribution of financial as well as hardware and paperwork contributions that finally took shape is shown on the next page.

The actual test installation was made at UL on July 11th. The installation was performed by industry project participants and went smoothly. UL began their test program soon thereafter.

# UNDERCARPET SYSTEM

## HARDWARE/MONEY/PAPERWORK CONTRIBUTIONS TO UL AND NEC EFFORTS

	MSFC	JSC/USPO	T+E	AMP, Inc.	T&B	PARLEX	BRAND-REX	LAMOTITE	C&A	MILLIKAN	DUPONT	WE	BELL LABS
HARDWARE													
• Cable.....						✓	✓						
• Taps, splices, splice covers.....				✓									
• Foil.....								✓					
• Foil connectors.....					✓								
• Receptacles and doghouses.....					✓								
• Flat-to-round junction (above floor).....					✓								
• Flat-to-round junction (duct).....				✓									
• Carpet.....									✓	✓			
MONEY FOR F.F. REPORT...	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
PAPERWORK													
• Request for F.F. report.....			✓		✓								
• Endorsement of F.F. report.....		✓											
• System specifications.....			✓									✓	✓
• NEC proposal.....	✓	✓	✓	✓	✓				✓			✓	✓

A study that is related to the UCSP FCC implementation projects began in July 1975 at the Center for Building Technology of the National Bureau of Standards. The study is sponsored by the Department of Housing and Urban Development (HUD). Its specific topics are non-metallic sheathed cable (Romex), and flat conductor cable. The parts of the study that are relevant to the FCC project are:

- A literature search and evaluation on electrically-caused fires.
- Evaluations of parts of National Electrical Code (NEC) relating to prohibitions or restrictions on FCC.
- Laboratory investigations of fire and electrical safety aspects of FCC.

The HUD/NBS study is aiding in increasing knowledge of and visibility of FCC systems. T+E has been working in close coordination with NBS on the FCC aspects of the study.

A final aspect of the July activity was an economic study on the effects of FCC on the demand for electricians in office construction. This study, reproduced as an appendix to this report, indicates that the lower cost of the undercarpet FCC system will substantially increase the new demand for electricians' time. FCC will increase new office electrification both by increasing the density of outlets and by slightly increasing the total amount of office construction undertaken.

### Third Quarter: August-October

After the UL test system was installed, T+E and the industry group began to turn their attention to developing the proposed new article for the National Electrical Code. Development of the NEC proposal began with a late August project meeting. The main features of the proposal were outlined, and the job of developing a preliminary draft proposal was given to the Thomas and Betts Co. The draft proposal was developed in time for a thorough review in early October. Most of the important issues surrounding the proposal were resolved at the October meeting. These issues included the appropriate temperature and voltage ratings for the system, and the proper location rating ("wet" or "damp"). With these primary issues resolved, the proposal was essentially in the final form in which it was submitted in December; only minor technical and language issues remained.

The Code proposal did not actually account for most of the activity of T+E and the industry group in the third quarter. Several technical shortcomings were discovered with the July test installation at UL that the original installation be replaced. Three separate problems were discovered:

- The taps and splices in the test system were unstable. Electrical continuity was incomplete, and unacceptable heat-rise occurred at certain taps and splices under overload conditions.
- The type of metallic shield installed used in the test installation was subject to tearing and cracking.

- The cable originally supplied was not capable of passing a water immersion test that was applied to it.

The first two problems related to UL's full-scale test layout. They required replacement of the original installation with a new, modified system. The reinstallation was completed in early October. The problem with the taps and splices proved to be a quality-control problem that was peculiar to the prototype hardware used in this particular installation. The problem with the metallic shield resulted from a decision to use a new, untested configuration in the first installation. A thicker shield of a type that had been used successfully at previous test installations was substituted in the second UL installation. These two modifications resulted in a reliable second installation that UL tested with favorable results.

The third problem arose from one of UL's bench tests of the undercarpet system cable. The test involved immersion of the cable in hot water with a potential applied across its conductors; it resulted in delamination of the cable insulation after a relatively short period of immersion. Its implications for the project of this test result were not immediately understood. By mid-October, however, it was apparent that it did not in fact constitute a problem for the NEC approval process: The NEC Committee is only interested in the feasibility and safety of the overall system concept, not in the performance of particular prototype components. And, in addition, the testing procedure that UL used turned out in the light of expert



analysis not to be an appropriate or meaningful test anyway for the undercarpet system cable for its intended uses. The performance of particular system components is an issue that will become important in the approvals process only after the NEC accepts the system; at this time (i.e., 1978) UL will develop detailed testing standards for each system component, that will serve as the basis of their listing procedure.

To summarize, the third quarter was a period of uncertainty and unanticipated activity for the project, yet, by the end of October, the technical issues that had arisen were satisfactorily resolved, and the development of the Code proposal was proceeding on schedule.

#### Fourth Quarter: November-February

The last quarter of the 1975 implementation project activities was the culmination of what had gone on previously. The activity revolved around two main events: finalization and submission of our Code change proposal, and a subsequent presentation of the proposal to the Code panel.

A meeting was held on November 10 to finalize the Code proposal. The industry group proposed numerous minor revisions at this time, which were incorporated into the final proposal draft. The meeting also reviewed and revised a set of system installation instructions that AMP, Inc. had prepared at UL's request for inclusion in their report. Finally, the group received a report on the progress of UL testing. The report indicated that the testing had been going well, and that no problems had been found with the new test installation. The cable in particular was performing very well in many of the electrical and mechanical abuse tests.

On December 1, T+E delivered the completed proposal and UL Interim Report to the National Electrical Code Committee, and our proposal was referred to the appropriate panel within the Committee.

At this time we began to plan the presentation we would be making to this panel at the NEC meetings in January at Tampa. Another meeting was held on December 16 to develop this presentation. The industry group determined that T+E should make the presentation, but that manufacturers' representatives

should also be on hand to answer technical questions.

The form and content of the presentation were considered in detail, and T+E undertook to write and circulate a draft of the presentation. AMP, Inc. offered to provide for the Code Panel a tour of their FCC demonstration installation at their research facility near Tampa. This idea was met favorably, and AMP and T+E undertook jointly to make the necessary invitations and arrangements.

A final meeting was held in early January to carefully review and revise the T+E draft presentation. T+E made the appropriate revisions, and prepared a slide show. On January 18, the NEC Panel members toured the AMP demonstration installation, and on January 19 David MacFadyen of T+E made the formal presentation.

The January NEC meetings were the first of two meetings that the NEC Committee is holding concerning the 1978 Code. The second meeting will be in December, 1976 at San Diego. Initial decisions were made on all proposals at the January meeting and the proposals and decisions will be published for comment in May. All proposals will be reconsidered in December and final decisions will be made. The Code Panel at the January meeting felt that they could not accept our proposal in the form in which it was presented. They did, however, provide detailed comments and suggestions for the proposal which, if addressed properly in the coming months,

will be likely to result in a positive final decision. T+E and the industry group, having examined in detail the nature of these comments, is at this time optimistic that all of the NEC's concerns can be met and that they will be satisfied with the feasibility and safety of the undercarpet system.

The Code Panel's specific concerns had in part to do with the form and content of the proposal itself, and in part with the incompleteness of UL's testing program at the time.

Regarding the form and content of the proposed article, the panel asked that it be rewritten to conform with the NEC's most recent style manual. The industry group had been under the impression that the Panel would do this themselves; but in any case it will be easy to do. Other concerns regarding the content of the proposed article included the need to properly specify cable markings, to clarify the term "approved carpet", and to demonstrate the advisability of using the system over radiantly heated floors.

With regard to the incompleteness of the testing program, the Panel asked two things: that long-term abuse testing of the UL installation be completed, and that additional tests of the long-term durability of taps and splices be undertaken. The abuse testing was a planned part of UL's test program that they had been unable to complete by December. This testing will require approximately six weeks, and is now planned for March and April. The additional testing of the long-term

performance of taps and splices is outside of UL's original test program. It reflects the NEC's concern that the taps and splices be particularly durable for this system, since they are concealed and permanent once they are installed. AMP, Inc., the manufacturer of these components, will perform the additional testing themselves, under UL's direct supervision.

At the end of the final quarter of the T+E Urban Construction and Safety Project, thus, full acceptance of the system by the NEC was not yet obtained, but was considered likely by both the industry participants and by T+E. Concrete steps were being undertaken to modify the Code change proposal and to complete the test program in accordance with the NEC Committee's wishes. The activities of the 1975 undercarpet FCC project were thus clearly successful. Industry commitment to the FCC concept is firmly established, and industry is taking an increasingly active and independent role in the FCC commercialization process.

### 3.1.3 Baseboard FCC Implementation Project: Chronology

The idea of an implementation project for the baseboard FCC system as an entity separate from the undercarpet project did not emerge until late April, as a result of the April 24th meeting with the FCC industry group. At this meeting, the industry attendees indicated that they did not wish to undertake commercialization of the baseboard system at the time. They saw much greater commercial potential in the undercarpet system, and wished to concentrate their resources on it.

As a result of this meeting, NASA decided to independently undertake a fact-finding study at UL to be carried out in parallel with the industry-supported undercarpet study. T+E acted as sponsor for NASA of this study, and Marshall Space Flight Center fabricated, delivered, and installed the necessary hardware for the test installation.

T+E continued to attempt to engage industry support for this investigation and for commercializing the baseboard system. In particular, Leviton was encouraged to participate, since their product line is highly compatible with this system. Although the contacted firms expressed interest in the project, no firm commitments were obtained.

A baseboard system project meeting was held on June 19th. The attendees were MSFC, UL, Leviton, and T+E. At this meeting UL outlined its proposed testing program for the baseboard system, including the wall and ceiling extension components.

The study they proposed was simpler than the undercarpet system study because there were precedents to the baseboard system investigation -- notably the Johnsonite surface-mounted non-metallic raceway, as well as the preliminary investigation of FCC that the Urban Development Corporation had sponsored in 1974. The only completely new part of the system was a wall and ceiling extension component that expanded the baseboard system concept and promised to substantially increase its usefulness.

A UL test installation was completed in late July. Test work was delayed by the high level of activity generated at UL by the undercarpet system, and did not get underway until well into August. One problem was soon noted -- defective cable perforations between the cable conductors in the cable supplied by Marshall were resulting in the electrical leakage in the metallic-raceway extensions of the system. This fault was corrected by supplying new, unperforated cable. By October, testing was proceeding routinely, and Marshall was developing a Code change proposal to accompany the undercarpet proposal.

In early November, however, the continuing test work revealed important safety issues surrounding the baseboard system. These issues would require resolution before the system became acceptable to the NEC Committee. Specifically, the non-metallic baseboard, as presently configured, is vulnerable to penetration by sharp objects; and due to

the flat configuration of the cable, the chances are high of penetrating a conductor. A metallic penetration is thus likely to be hot, and presents a shock hazard to building occupants. UL also found that when multiple cables are installed in a single raceway, the system may present a fire hazard.

These problems are by no means unsolvable; Marshall Space Flight Center is currently investigating several different solutions. However, since these problems were clearly identified only in November, there was no opportunity for a fix to be made before the December 1 NEC proposal deadline. The decision was made not to submit a proposal at all for the baseboard system. The main reason was the concern that the unavoidable weakness of such a proposal would tend to raise doubts about the undercarpet system, despite the absence of any identifiable problems with that system. The decision to terminate UL's investigation of the baseboard system for the time being was formally made in mid-December. UL prepared a detailed letter report of their investigation to aid Marshall in developing and testing a modified configuration. Marshall expects to reactivate the UL study when a modified system is available.

T+E expects that the baseboard system will ultimately be commercialized. How long the process takes depends on the level of effort that NASA wishes to expend. The process can



be speeded by a continuing implementation project. If such a project is not undertaken, the implementation process will take considerably longer, and can only occur as an adjunct to the success of the undercarpet system.

### 3.2 Flood Insurance Studies

As a consequence of recent legislation, the Federal Insurance Administration (FIA) of the Department of Housing and Urban Development (HUD) is required to perform surveys of all flood-prone communities in the United States in order to determine what flood insurance rates should be set for different areas of each community. In coming years, up to 20,000 communities will need detailed surveys, at a total cost of up to \$750 million. Less than 1,000 communities have so far been surveyed. The remaining surveys will have to be performed quickly, to high standards of accuracy and in the face of formidable pressure to control the costs.

The FIA is seeking help from NASA to improve their flood insurance study methods. The Urban Construction and Safety Project has taken the responsibility to work with the FIA in identifying and assessing possible NASA technologies.

#### Background

A detailed Flood Insurance Study, among other things, results in a map showing that portion of the community studied which will be flooded by a 100-year and a 500-year flood, together with the elevations of the 100-year flood. Also shown is the delineation of a floodway which is that channel of the stream required to carry and discharge a 100-year flood without undue rise in the flood water level. Either ground surveys or photogrammetry may be used to obtain the cross-sections.

In very simplified terms, developing this map for a riverine area requires obtaining numerous cross-section surveys of the stream being studied, estimating roughness coefficients of the

stream bed, and determining the peak discharges for various flood frequencies. Several computer programs are available which will convert this information into 100- and 500-year flood profiles which are then plotted on a contour map. This is subsequently used to produce the Flood Insurance Rate Map. The floodway delineation also is obtained from the computer printout and, modified with professional judgment, is plotted on the same map. Frequently, the flood profile and floodway must be correlated with earlier studies in the vicinity and coordinated with local officials so that some recomputation (trial and error work) is necessary.

FIA's major concern is with the high cost of their studies.

The cost items are as follows:

- Surveying ordinarily represents the largest single item of cost on a project. Costs from 1/3 to nearly 1/2 the total project costs were cited. Photogrammetry, which seems to be used increasingly for surveying, particularly on the larger streams, reduces this cost somewhat but does not reduce it to an insignificant amount.
- Drafting, map reproduction, printing, etc., may also be major cost items, especially on larger projects. Studies involving a few hundred plates for the final report are cited as examples of situations where such costs are important, and may involve 1/3 of the total project costs.
- Analytical work--discharge computations, computer runs, profile analysis and floodway determinations--seems to represent a small part of the total cost of a project. Generally, the major cost item in this category is related to the work associated with the computer program. This includes preparing input data, analyzing the printout, readjusting the input data, and rerunning the program until the results fit historic data and other previously conducted studies. Complex projects involving several earlier studies on contiguous areas can cause substantial increase in the cost of this work.

A very large number of flood studies will be required for the Flood Insurance Administration to carry out its responsibilities. Thus, any cost reductions which can be accomplished in a study could have enormous benefit over a period of time. Opportunities for cost reduction are offered by the application of advanced technology, such as surveying, analysis, and drafting.

Although FIA's Flood Insurance Studies are done as carefully as possible, FIA does not feel that their present methodology is in any sense a definitive or optimal procedure; on this basis, they are open to the adoption of any new approaches that are demonstrably as accurate. They do not bar the possibility of substantially increasing accuracy through technological breakthrough.

In addition to the formal flood insurance studies, there are other activities of importance to FIA for which NASA assistance could be very appropriate. These activities include:

- Performing preliminary hazard evaluations. Prior to undertaking formal surveys, FIA performs initial hazard delineation surveys. These surveys are primarily performed using existing maps. Unfortunately there are some areas for which satisfactory maps do not exist. Landstat or aerial multispectral imagery may be useful for these cases.
- Monitoring floodplain development. Part of FIA's mandate is to issue guidelines for floodplain development, and to monitor this development. At this time, with present techniques, FIA has no feasible way of monitoring floodplains.
- Understanding the effects of development and urbanization on stormwater runoff. Changing land use patterns will markedly affect runoff, and therefore flooding characteristics. FIA does not currently know how to monitor and model these effects.

T+E has been treating these problem areas as topics for consideration, as well as FIA's formal flood insurance studies.

#### The T+E Flood Insurance Study Project

Throughout the course of the 1975 project, T+E worked with FIA to identify, assess, and apply NASA technological inputs to flood insurance studies. This activity has recently born fruit: FIA is about to fund NASA to demonstrate several applications of NASA technologies to specific phases of the flood insurance study process.

In the months preceding the formal start of the 1975 project, T+E researched the flood insurance study topic and laid the groundwork for the subsequent activity. T+E Senior Scientist James Simpson wrote a comprehensive paper entitled "Potential for the Application of Advanced Technology to Flood Elevation Studies of the Flood Insurance Administration" (reproduced in Appendix 5.2.1). This paper describes the general process of conducting a flood insurance study, and identifies the major constraints to their timely, accurate, and economical completion. Based on this paper, three problem statements were generated and disseminated. They relate to the three primary areas of activity in conventional flood insurance studies, namely:

- surveying
- hydraulic analysis
- map-making and reproduction.

At the beginning of the 1975 project, this paper was extensively revised and updated on the basis of additional research. A

fourth problem statement was added that was designed to elicit totally new approaches to flood insurance studies, such as use of remote or satellite imagery.

These problem statements were redisseminated at the beginning of the second quarter of the project. By the fall, several groups of technologists doing relevant work had been identified, at Goddard, at Marshall, and at Jet Propulsion Laboratories. During this time, also, T+E continued to work closely with FIA in refining our initial definitions of the problems. A new Assistant Administrator for budgetary matters joined FIA in the course of the year, and strongly encouraged us to move ahead to promote a NASA/FIA dialogue.

T+E organized a meeting between FIA and NASA that was held on December 5. (The minutes of this meeting are reproduced in Appendix 5.2.2.) NASA was represented at the meeting by technologists from Goddard and JPL. The meeting proved to be enormously successful, in terms of both increasing insight into the areas of possible NASA/FIA cooperation, and generating momentum for further action. Albert Rango, the Goddard technologist at the meeting, described work that he had done in flood and floodplain mapping using Landsat imagery. The JPL technologists described the large effort they have been undertaking to apply sophisticated image processing technology to remote mapping imagery. Both these efforts have clear relevance to FIA's needs. Briefly stated, the conclusions of the meeting were as follows:

1. Remote sensing, multispectral analysis, and automated image processing are likely to be useful for the 3000 preliminary flood hazard boundary studies that remain to be performed. They could comprise the dominant approach for this work.
2. Applications of NASA technology could eliminate the need for the present step-backwater analysis in detailed Flood Insurance Studies and would represent a major efficiency in the process. Multispectral analysis may improve the reliability of flood boundary data sufficiently to allow this innovation.
3. As a step to refining and utilizing remote sensing and multispectral analysis in both 1 and 2 above, the accuracy and reliability of these techniques need to be carefully studied as well as the discrepancies noted between NASA's floodplain delineations and the conventional delineations.
4. NASA image processing systems can cut labor costs by combining and correlating Flood Insurance Study inputs and automatically printing out the resultant rate zone maps.
5. NASA remote sensing and image processing can aid in early planning and development information; in floodplain development monitoring; in comparing floodlines with actual floods; and in damage assessment.

As a consequence of this meeting, three follow-up activities occurred in December and January:

- T+E produced a background paper based on the discussion at the meeting that defined a number of flood insurance study areas to which NASA technology is likely to be applicable.
- Based upon the T+E paper and upon their own conclusions, the JPL group wrote a concept paper for FIA describing six specific feasibility and demonstration studies that they could initiate with FIA funding.

- A working session was held to develop specific approaches for NASA assistance to FIA's preliminary flood hazard boundary studies.

The T+E background paper and the JPL concept paper are reproduced in Appendices 5.2.3 and 5.2.4 respectively.

FIA is currently in the process of examining the JPL concept paper, and has indicated that they are seriously considering funding two and possibly three of the six JPL options:

- Preliminary floodplain delineation from Landsat.
- Floodway urban development monitoring.
- (possibly, after completion of the above) Modelling of the impact of urbanization upon stormwater runoff.

In addition to these three options, FIA is still evaluating a fourth JPL option, the use of a new type of airborne scanning laser altimeter to measure floodplain profiles.

T+E considers it very likely that FIA will fund at least the first two, and perhaps one or both of the latter two, of these options. T+E considers that its role as a catalyst in promoting NASA/FIA interaction has been highly successful. T+E's role in this implementation project is at this point largely complete, now that the technical dialogue has started. T+E is continuing, however, to track the project closely and with interest.



### 3.3 Tornado Studies

In response to Congressional interest in tornado problems and tornado-related research, the 1975 Urban Construction and Safety Project has looked in some detail at possible applications of NASA technology to this field of study. In May, Jim Simpson, USCP Senior Scientist, interviewed nineteen administrators and scientists at different universities and government agencies to define the nature of the tornado problem and to assess the scope of current research and future research needs.

The results of this inquiry was a paper entitled "Tornado Related Building Research in the U.S.A.--A Brief Overview."

The conclusions of this paper were as follows:

- The most damaging aspects of tornadoes appear to be the high winds, either alone or in combination with flying objects. The pressure drop at the vortex is felt to be less important.
- Current tornado-related research is primarily being carried out under the auspices of the National Science Foundation (NSF) and the National Oceanic and Atmospheric Administration (NOAA). NSF has been primarily studying the engineering aspects of the problem, while NOAA has been concerned with storm mechanisms.
- There is a clear need for more research, in practically every tornado-related area.

Inquiries are needed in the following specific areas:

- Meteorology: Studies are needed of the wind forces and pressure gradients generated by tornadoes; the conditions that trigger them; their rate and path of travel; and prediction and detection. An inexpensive and reliable warning device for those in tornado paths would be worthwhile.
- Fluid Mechanics: How wind interacts with buildings, especially in connection with flying objects.

- Structures: Failure modes; "minimum life-cycle cost" design methods.
- Analytical Modelling of the dynamic characteristics of storms and buildings.
- Wind Tunnel Work: Calibration, instrumentation, data for use in modelling.
- Reconnaissance and Storm Probing, to analyze storms in progress and to quickly assess storm damage.

In July, the UCSP inquired into the status of existing tornado work at NASA. In particular, an informative visit was made to Milton Huffaker, a Marshall Space Flight Center technologist who is studying dust devils in cooperation with the National Oceanic and Atmospheric Administration.

The main conclusion of this meeting was that although there is a large and well-coordinated program under the NASA Office of Applications to study tornadoes from a meteorological point of view, there appears to be no systematic work going on related to tornado damage and tornado-safe engineering.

A clear research opportunity was identified in this area. T+E worked to identify interested NASA technologists, and several were identified. One of these technologists is Dr. Lawrence Pleimann, formerly of Johnson Space Center, who recently moved to the University of Arkansas (U.A.). T+E worked with Dr. Pleimann to develop a NASA-funded research project. Dr. Pleimann developed and submitted to NASA Headquarters a proposal to study the tornado safety engineering of critical buildings.

### 3.4 The "Project Tech" House

The NASA House, or "Project TECH" house is a concept for a house to be constructed to demonstrate applications of NASA technology and other state-of-the-art innovations to residential construction. Construction is planned at Langley Research Center, to be completed in time for the Bicentennial. A second house is planned for Kennedy Space Center.

Urban Construction and Safety Project team members have participated in this effort since its inception in 1974. In the past year T+E inputs have included

- A background paper by James R. Simpson, "Recent Demonstration-Type Houses in the U.S.A. - A Brief Review."
- Assistance in soliciting inputs to the House from the various centers.
- Arrangement for the participation of the National Association of Home Builders (NAHB) Research Foundation in the design of the House, and of the Consumer Product Safety Commission (CPSC) to define needs for safety technologies.
- T+E let a subcontract in late summer to the NAHB Research Foundation to provide formal design input and evaluation assistance for the House. Since then, NAHB has worked closely with the Langley project sponsors.

### 3.5 Assistance to the City of Atlanta

Last summer, the Commissioner of Budget and Planning for the City of Atlanta sent a letter to the NASA Administrator requesting NASA assistance in two areas: the definition and measurement of environmental habitability; and techniques

for resource management and allocation. This request was assigned to T+E for action. T+E met at length with the Commissioner to better define the possibilities for NASA assistance. T+E conducted a database search, and also contacted the primary NASA-associated technologist working in the environmental habitability area, who gave us several reports and additional contacts. These materials were forwarded to Atlanta.

### 3.6 Diesel Engine Controller

At the request of Johnson Space Center, T+E initiated in May a brief study with Technical Marketing Associates (TMA) of Concord, Massachusetts on the market potential for a new Johnson-designed solid state control system for stationary diesels. The TMA study concluded that the system is fully workable but does not represent a fundamental improvement over existing designs. In July, the study was presented to the JSC technologist, Leo Monford, who initiated the design. Leo felt that the market study missed certain important features of his design, notably its potentially much lower cost and its easy replaceability. T+E carefully reviewed the TMA study and determined that the new controller was of possible merit. We decided to identify one or two large users of stationary diesel controllers to work with Leo to evaluate his design and to better specify the areas of needed innovation. We identified the U.S. Military as the

primary user and information source in this area. Five contacts in the Army, Navy, and Department of Defense were located. All of them expressed interest in working with NASA, and their names were passed on to JSC.

### 3.7 Mobile Home Testing

Under Congressional mandate to prepare national mobile home standards, HUD has been seeking short-term assistance from NASA and NBS to research the areas of wind, transportation, and structural factors. Last summer, HUD contacted T+E to explore possible NASA assistance.

T+E contacted Langley Research Center and Ames Research Center concerning the availability of their full scale wind tunnels for possible mobile home testing. Unfortunately, the Langley tunnel was down until March 1976 and the Ames tunnel was booked through February 1976. In a conversation with the Ames TU officer Chuck Kubokawa, T+E determined that real-life gusting situations could not be simulated in a wind tunnel anyway and that a full-sized mobile home probably would be too large for proper wind tunnel tests.

T+E also contacted R.C. Goetz, head of the Dynamic Loads Branch of the Langley Structure and Dynamics Division. He offered guidance in instrumentation and analysis and lent some instruments such as stress gauges and accelerometers, but could not commit time or facilities to mobile homes.

Thus T+E and NASA were able to provide little assistance to HUD. T+E place HUD directly in touch with Ames and Langley, to permit future NASA/HUD cooperation, if circumstances change.

#### 4.0 CONCLUSION

T+E would like to conclude this report by noting two areas in which we feel that we have achieved significant insights into the conduct of the factors that promote effectiveness in technology transfer activities. These two areas are tech search and access, and externalization of leverage. These are discussed in turn in sections 4.1 and 4.2 below.

##### 4.1 Leverage

The detailed conduct of an implementation project is highly operational in nature; there is no cut-and-dried "methodology" that can easily be described.

There are, however, certain considerations that should be addressed to facilitate an effective implementation project. The most important considerations are the appropriate trade-off between costs to NASA of the implementation project and the amount of time it takes to carry it out. It is sometimes possible to substantially reduce costs to NASA without substantially lengthening the time frame of the project. The technique involves externalization of activity and may be referred to as leverage. It may be described as follows:

The relative costs of the various stages of the technology transfer process are not always the same, and are not always proportional to the relative importances of the elements. Most frequently, costs are instead proportional to the time required to accomplish the given step. It is important to recognize the

distinction between those steps that require little effort, and yet greatly speed up the transfer process; and those steps that require much effort without proportionally large payoff. Steps of the former type--those with quick payoffs that can be efficiently accomplished--should be accomplished by the TATeam. Steps of the latter type, that do not offer these efficiencies, should be carefully examined to determine whether they can be externalized without a major time penalty to the process. Externalization of steps of this type is what is meant by leverage.

Externalizing elements of the technology transfer process may be time-consuming, and it reduces the amount of control that NASA of the TATeam has over that particular transfer. Similarly, the externalization of the applications engineering required to adapt NASA technology for public sector problems does away with an opportunity for a center RTOP to accomplish the same application with greater NASA control. Decisions must be carefully weighed based upon the leverage that can be accomplished through external actors.

Our undercarpet Flat Conductor Cable project is a significant example of how implementation costs can be usefully externalized. The nature of the applications engineering involved in the FCC project made it difficult for the Team or for NASA technologists to accomplish the required applications engineering. This function was therefore externalized to private industry; a group of ten manufacturers and potential system users



formed a joint development project. The industry participants not only provided the necessary expertist to effectively carry out the project; they also supplied most of the funding for the testing program that was required for the Code approval process. Thus, NASA resources were substantially leveraged in a way that facilitated quick success of the project.

The lesson is that it is in certain cases possible for NASA TU activities to be highly discretionary concerning funding, without loss of time and project effectiveness. Each case must be considered on its own merits; but the possible resource savings will in certain cases be substantial.

#### 4.2 Tech Search and Access

The Urban Construction and Safety Project at T+E has long recognized that the main constraint in the NASA technology transfer process has been the problem of how to effectively access NASA solution technologies. When problem statements are disseminated to field centers, feedback has for the most part been minimal. The reasons have not been clear. Possible reasons have been that the problem statements have not been widely enough disseminated at the centers or have not been disseminated to the right technologists; or that the technologists have been either not motivated or not able to respond.

In an effort to get to the root of this problem, T+E made the first of a planned series of visits to field centers in July.

On July 9th and 10th, T+E visited the Technology Utilization (TU) Office at Marshall Space Flight Center (MSFC), as well as several center technologists. The purpose of the trip was not only to increase our understanding of center tech access procedures and constraints, but also to improve communications with the center visited and to survey available center technologies in several areas of current interest to us.

The first part of the meeting was built around a slide presentation of the purpose- context, and operation of the UCSP. The second part of the meeting was aimed toward obtaining feed-back from the MSFC attendees. Aubrey Smith, the MSFC TU Officer, was first asked what he thought would be effective ways for us to interace with center technologists. Two primary scenarios for tech access activities were identified: (1) to brainstorm intensively with a small number of technologists (4 or 5) and cover perhaps three problem areas in one day; and (2) to choose 100 technologists who might have inputs, and circulate problem statement to them. The second approach has the advantage over the first of being less expensive.

Next the problem was addressed of why technologists may not respond to problem statements for which they have input. The following points emerged about the committments and motivations of technologists:

- The natural reaction of technologists is to want to solve problems.

- Technologists are constrained, however, by man-hour allotments that require that they spend their time in particular ways.
- It is therefore more a question of facilitating than motivating response to urban construction and safety problems.
- Technologists' inputs would be best facilitated by having time allotments and work account numbers for acting on problem statements.
- A discretionary budget to pay for technologists' work on Urban Construction and Safety problems could be made available through the TU Office from Bill Smith. An advance set-aside is also needed for shopwork.
- Our problem statements should be disseminated via the Lab Directors, in part because the Directors can best distribute them in useful directions, and in part because their authority will legitimize working on them.
- To accomplish this arrangement, it will be necessary to work from the ground up to establish communications with the Lab Directors (most Lab Directors don't know about the UCSP). This would be most appropriately the job of the TU Officers.

Thus, it appears that our tech access activities should follow the general NASA trend towards establishment of formal linkages, procedures, and budgeting. The availability of discretionary funds at the centers appears to be an essential element of any strong tech access program.

## 5.0 APPENDIX

### 5.1 Flat Conductor Cable

5.1.1 D.J. MacFadyen: Presentation to National Electrical Code Committee, 19 January 1976

5.1.2 R.F. Stone: "The Effect of Flat Conductor Cable on the Demand for Electricians in Office Construction"

5.1.3 Summary of FCC Project Participation

### 5.2 Flood Insurance Studies

5.2.1 J.R. Simpson: "Potential for the Application of Advanced Technology to Flood Elevation Studies of the Flood Insurance Administration"

5.2.2 Minutes of December 5, 1975 Flood Insurance Study Meeting

5.2.3 P.T. Hogarth: "Possible NASA Inputs to FIA's Flood Insurance Study Procedures"

5.2.4 Jet Propulsion Laboratories: "Potential Demonstration Tasks for Federal Flood Insurance Studies"



## APPENDIX 5.1

### 5.1.1

D. J. MacFadyen

Presentation to National Electrical Code Committee

19 January 1976

(tentative)

The subject of this proposal is a Flat Conductor Cable wiring system for branch circuits. The proposed wiring system is to be mounted on the floor, protected by a metallic shield, and covered by a resilient floor covering. The cable and hardware, when covered by carpet, are undetectable.

First, I would like to briefly explain how the undercarpet wiring system came to be developed, and the needs it promises to fill.

This system is a spin-off from the Flat Conductor Cable technologies that have been developed for aerospace applications. After two decades of aerospace and military applications, the technology is now finding increasing commercial usage in the computer, automotive, and aircraft industries. An example of a recent application is undercarpet wiring in the cabin of the 747 airliner--a close analogy to the use we are now proposing. Flat cable telephone systems are already in use and rapidly expanding. The properties of Flat Conductor Cable are well understood.

Development work on Flat Cable systems for building wiring has been proceeding for several years now. In the past year, a group of ten concerns, manufacturers and users, have worked with NASA to develop the concept into a well-designed power system for office and commercial space. These companies have shared the developed work and the costs of system testing. The ten companies are:

- AMP, Inc.
- Bell Telephone Laboratories
- Brand-Rex Corporation
- Collins and Aikman Corporation



- E. I. DuPont de Nemours & Co., Inc.
- Lamotite Products
- Deering Milliken, Inc.
- Parlex Corporation
- Thomas & Betts Co.
- Western Electric Company

Technology + Economics, Inc., the company I represent, is coordinating the effort. We are under contract to NASA to assure that their technology is applied to appropriate construction industry problems. The interest that industry is showing in the undercarpet wiring system is a result of its obvious value for certain types of building electrification needs. Unique needs exist in the electrification of office and commercial space. One notable problem is mid-floor outlets in high-ceilinged lobbies. A number of institutions, such as banks, have spaces of this type which are very difficult to electrify to accommodate moves and re-arrangements. The usual solution where existing ductwork is not adequate involves drops from the ceiling; with high ceilings this method is not possible.

More generally, the undercarpet system copes with change. The typical situation today is often as follows: An office space user needs to alter or expand his electrification to meet changing needs. To alter his existing ducted wiring system would entail more expense, mess, and disruption than he is willing to undertake. As a result, the office changes, but the occupants still have their additional needs, and they try to meet them by jury-rigging a system of extension cords, multiple outlets, and so forth, that is inconvenient, and more importantly, unsafe. We are all familiar with the "christmas tree" receptacle with many too many loads attached, trip-prone extension cords, over-the-carpet ducting systems, and other occupant-devised dangers. An alternate system utilizes drops from the ceiling. These drops have serious aesthetic and flexibility disadvantages and are

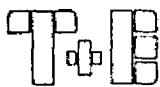


unacceptable to many designers for these reasons. Even under-floor duct systems constrain receptacle locations, often resulting in unsightly or unsafe situations. At a minimum, the fixed receptacle locations dictate furniture location, often inappropriately.

The proposed undercarpet system is surface-mounted and is designed to be easily changed and expanded. It offers complete flexibility regarding the location of outlets. It is also designed to be interfaced with existing systems: flat cable can, for example, be run from an existing underfloor raceway. The result is a safe, practical, and aesthetically satisfactory wiring method. In the past, an office user faced with needed office modifications would often be unwilling to properly modify the electrical system, and would attempt to jury-rig an unsatisfactory solution. With the proposed system he will be able to relocate, add or remove outlets and still have a safe, workable system professionally modified without carpet damage and with minimum inconvenience. Additional advantages arise when the wiring system is used in conjunction with an under-carpet flat cable telephone system. In short, with the undercarpet system, the tailoring of electrification to constantly-changing user needs will now become a practical reality.

I'll now describe the system tested by Underwriter's Laboratories for the fact-finding report. This system was assembled and tested to demonstrate the feasibility of the system concept. Of course, with passage of the code, industry will develop code-complying systems and components that may be different.

The Flat Conductor Cable was composed of three copper conductors having the same cross section as 12-gauge wire. The floor-mounted cable is protected by a "top metallic shield" and a "rear (or bottom) non-metallic shield." The top shield covers and provides mechanical protection for the electrical components. It has current carrying capacity equal to each



conductor and assures that, if a metal object penetrates the shield, sufficient contact will be made to carry the fault to ground and trip the circuit breaker.

The purpose of the non-metallic rear shield is to provide mechanical protection to the system when it is laid on a rough floor. This shield was coated with adhesive on both sides--the upper layer of adhesive bonds the rear shield to the cable and to the top shield; the lower layer of adhesive anchored the entire system firmly to the floor.

Cable taps and splices were made by means of connectors developed specifically for this purpose, and were installed by means of a special tool. The installation sequence I am showing here is also reproduced following Page 10 of the Fact-Finding Report. The splice or tap assembly was covered to form an insulating, water-resistant bond with the cable, tap mount, and rear shield. These joints were covered by the same metallic shield that covered the cable.

The taps, splices, and corners of the metallic shield system are capable of carrying the same fault current as the unbroken shield.

The receptacles that were used are basically similar to the designs for conventional round-wire system. The receptacle installation sequence is illustrated in Figures 6, 7 and 8 of the Fact-Finding Report. The flat cable was attached to a terminal block within the receptacle housing, and pigtail leads were run from the terminal to the receptacle.

The system was powered from a round-wire system by means of a similar terminal block.

This completes the description of the major components of that system.

Considerable effort has gone into making the undercarpet Flat Conductor Cable systems safe and reliable. The development work upon which the system builds involves long experience with the cable itself, and with the accompanying connector technology.





The aerospace applications of flat cable have been uncommonly demanding, involving extremes of temperature, and requirements for complete reliability, light weight, and durability. Underwriters Laboratories' fact finding tests indicate that the same performance is achievable for building electrification.

The Underwriters Laboratories' testing program is treated in detail in the Interim Fact Finding Report and subsequent letters that you all have. The test results demonstrate the feasibility and safety of the system.

The results show the flat cable system performs at least comparably to, and in many cases better than approved systems under similar loads. The favorable test results indicate the soundness of the connection method, and in addition they show the excellent heat dissipation properties of the flat configuration of the system.

In addition to the UL test set-up, there have been several field test installations of similar undercarpet systems. We have thus had the opportunity to observe systems in occupied offices. They are standing up well.

The National Electrical Code (NEC) as presently written does not allow use of the undercarpet flat cable system. You have before you a copy of our proposal to change the NEC to permit its use. The Code change proposal is structured as an entirely new article. I will not go over it in detail, but just point out its major features. Basically, the proposal allows a system configured in general as I have just described. It does, however, allow considerable flexibility for developing improved system components and installation techniques. It sets guidelines for system performance and conceptual design, rather than specifying materials and hardware. Components would have to meet the UL standards to be developed on the basis of a new Code article. It should be noted that this proposal is specifically not designed around any one manufacturer's methods and capabilities. The very fact that a group of ten manufacturers

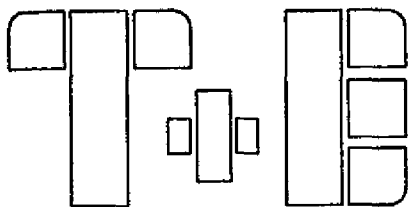


and potential system users developed this proposal eliminates the possibility.

The following features of the proposed Code section may be noted:

- The system is designed to be installed under suitable carpeting, and also under appropriate types of resiliently-backed smooth-surfaced tile.
- Use in damp locations is permitted.
- Use on heated floors is permitted, provided that suitable materials are used.
- It has been tested so far for single-phase, 20 ampere circuits, but the Code proposal makes provision for poly-phase, 30-ampere appliance circuits as well.
- The system cannot be left exposed (that is, without a floor covering) and may not be installed in wet or hazardous locations.

This completes a quick outline of the system we propose. We would like to take the opportunity in the next few minutes to clarify any of the points I've raised, and to answer your questions.



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## APPENDIX 5.1.2

DRAFT REPORT August '75

The Effect of Flat Conductor Cable on the  
Demand for Electricians  
in Office Construction

by  
Robert F. Stone

# The Effect of Flat Conductor Cable on the Demand for Electricians in Office Construction

## I. Introduction

There are three ways in which the substitution of flat conductor cable for conventional wiring can affect the demand for electricians in office construction markets. First, insofar as the installation process is modified by the substitution of flat conductor cable for conventional wiring, the relative intensity of electrician man-hours per square foot of office construction may be either increased or decreased. For the sake of brevity, we shall term this change in the production process, the "process effect". Second, insofar as the substitution of flat conductor cable for conventional wiring reduces the total cost of electrical work in construction, on the margin more new office construction and more retrofit activity will occur, with a concomitant increase in electrician usage. We shall term this change as the "construction effect". Third, insofar as the substitution of flat conductor cable reduces the square foot cost of electrical work in construction, making electrical work a relatively cheaper input, on the margin the electrical component in a building may be increased (e.g., more outlets), again with a concomitant increase in electrician usage. We shall term this the "outlet effect". In the sections that follow, we shall attempt to derive broad estimates of the process effect, the construction effect, and the outlet effect in order to determine the total effect of flat conductor cable on the demand for electricians in office construction.

## II. The Process Effect

Although the precise nature of the modification in the production process caused by the application of flat conductor cable is dependent upon specific characteristics of the office being constructed, we estimate the relative cost per desk for electrification by conventional means and by flat conductor cable to be as follows:<sup>1</sup>

<u>Electrical Component</u>	<u>Conventional</u>		<u>Flat Conductor Cable</u>	
	<u>Power</u>	<u>Telephone</u>	<u>Power</u>	<u>Telephone</u>
Conduit Cast-in Slab	\$130	\$270	\$100	\$70
Wire	5	8	50	30
Receptable	3	15	13	27
Electrician Labor	12	12	12	12
Total	\$150	\$305	\$175	\$139

As can be seen, the substitution of flat conductor cable for conventional wiring apparently does not affect the production requirements for electrician man-hours per square foot, which remain constant, when expressed in dollars of electrician usage, at \$12 per desk or \$.24 per square foot.

<sup>1</sup>These estimates were derived by Jack Balde from his experience in Western Electric office construction. We shall assume that there are approximately 200 sq. ft. (gross) of office space per desk.

### III. The Construction Effect

The construction effect can be estimated by multiplying the percentage cost reduction from the substitution of flat conductor cable by the price elasticity of (derived) demand for office construction.

In Section II, we saw that the total cost of electrification was reduced from \$455 per desk to \$314 per desk (or from \$2.28 per square foot to \$1.59 per square foot) when flat conductor cable was applied instead of conventional wiring. This represents a 44.9% decrease in wiring costs. If we assume that office construction costs are approximately \$25 per square foot,<sup>2</sup> then conventional wiring costs represent 11% of total office construction costs.<sup>3</sup> The total cost savings that can be attributed to flat conductor cable, then, is 44.9% of 11%, or a 4.94% reduction in the total cost of office space.

The demand for office construction is a derived demand. Retailers, manufacturers, and other users of office space do not

<sup>2</sup>The F. W. Dodge 1971 Construction Forecasts projected 1975 costs per square foot of office construction to be \$19.13 (with 630 million square feet of construction at a total cost of \$12,050 million). Abt Associates' MIUS Marketing Considerations (1973) estimated costs per square foot of office space to be \$27.95, so that inflation of this estimate would put 1975 costs at over \$30 per square foot. We used the average of these two projections to arrive at \$25 per square foot.

<sup>3</sup>The electrical content of new office construction is 17.4%. (Source: Abt Associates' A Brief Survey of the Market for Surface-Mounted Flat Conductor Cable and Selected Electrical Equipment and Supplies (1970)). However, wiring constitutes only a portion of the total electrical content.

market office space per se, but rather employ office space as an input in the production or marketing of a final product. The demand for office space is derived from the demand for final products.

The economic literature really does not contain estimates of the elasticity of (derived) demand for office space.<sup>4</sup> However, we

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<sup>4</sup>The economic literature contains two types of related estimates, neither of which is appropriate for our purposes. First, the economic literature contains studies of elasticities of demand for various consumer products, but not for investment products (inputs). See, for example, H. S. Houthakker and Lester D. Taylor, Consumer Demand in the United States, 1929-1970; Harvard University Press, Cambridge, Massachusetts, 1966 and H. S. Houthakker, "New Evidence on Demand Elasticities", Econometrica, Vol. 33, No. 2, 1965. The former source contains estimates of the elasticity of demand for rental space of owner-occupied housing (long run elasticity of  $-.9837$ ), but the market for office space is so different from the market for housing that we are unable to apply these estimates. Second, the economic literature contains econometric models of U.S. investment. See, for example, L. R. Klein and A. S. Goldberger, An Econometric Model of the United States, 1929-1952, North-Holland Publishing Co., 1955 and J. R. Meyer and R. R. Glauber, Investment Decisions, Economic Forecasting, and Public Policy; Harvard Business School, 1964, and M. Evans, "A Study of Investment Decisions", Review of Economics and Statistics, May, 1967, pp. 151-164. However, these models do not estimate investment as a function of the cost of capital equipment (invariably, the business cycle or some surrogate is employed as the major independent variable); hence, no elasticity of demand for office space is derived in the economic literature. In Dale W. Jorgenson, Jerald Hunter, and M. Ishag Nadiri: "A Comparison of Alternative Econometric Models of Quarterly Investment Behavior", Econometrica, March 1970, pp. 187-212. a price elasticity of demand of unity is assumed for all investment goods, but this assumption is not substantiated by the authors.

can obtain a value for the elasticity of demand for office space,  $\lambda$ , if we know the value of the following four variables: (1) the (average aggregate) demand for final products,  $M$ , from which the demand for office space is derived; (2) the share of total cost for final products,  $k$ , that the cost of office space constitutes; (3) the elasticity of (technical) substitution of office space,  $\sigma$ , for all other (aggregate) inputs in the production for final products; and (4) the (aggregate) elasticity of supply,  $e$ , for all other production inputs. The effect of these variables on the derived elasticity of demand can be seen by the following four rules:<sup>5</sup>

- The derived demand for anything will be more elastic, ceteris paribus, the more elastic is the demand for final products for which it is an input.
- The derived demand for anything will be less elastic; ceteris paribus, the larger the share of total cost for final products it contributes;
- The derived demand for anything will be more elastic, ceteris paribus, the more readily that substitutes for that can be obtained;
- The derived demand for anything will be more elastic, ceteris paribus, the more elastic is the supply of all other factors employed in the production of final goods.

The equation we shall use to specify the elasticity of derived demand,  $\lambda$ , in terms of  $M$ ,  $k$ ,  $\sigma$  and  $e$  is the following:<sup>6</sup>

<sup>5</sup>Originally derived in Alfred Marshall's Principles of Economics. See also A. C. Pigou, Economics of Welfare; and Milton Friedman, Price Theory.

<sup>6</sup>Derived in J. R. Hicks, The Theory of Wages.



$$(1) \quad \lambda = \frac{\sigma(M+e) + \frac{1}{2}e(M-\sigma)}{M+e - \frac{1}{2}(M-\sigma)}$$

We shall assume  $M$ , the aggregate elasticity of demand for all final products in which office space serves as an input, to have a value of unity. This is not inconsistent with similar assumptions, both implicit and explicit, made throughout the economic literature.<sup>7</sup> We shall assume that office space, in the aggregate, constitutes approximately 30% of the cost of "producing" final goods. Clearly, for any specific product, the percentage may vary from 10% to 50%; however, our average estimate of 30% certainly should not be far off.

The elasticity of substitution,  $\sigma$ , of office space for all other relevant production inputs is more difficult to estimate, particularly because  $\sigma$  does not have a simple intuitive interpretation. If  $\sigma = 0$ , then the production function is characterized by fixed proportions; if  $\sigma = 1$ , then the production function exhibits constant returns to scale. We believe that the elasticity of substitution for office space falls somewhere between the fixed proportions production function and the constant returns to scale production function.

Similarly, the aggregate elasticity of supply,  $e$ , for all other relevant production inputs is relatively difficult to estimate in any straightforward manner. We believe that its value, which is dominated by the supply of labor and capital inputs, rests somewhere between .5 and 1. The relative inelasticity of the supply of labor would probably place an upward bound on  $e$  at 1; the relative elasticity

<sup>7</sup> For example, Arnold C. Harberger in "Monopoly and Resource Allocation", American Economic Review, May, 1954, pp. 77-87, makes this assumption in estimating the deadweight loss due to monopolistic resource misallocation.

of the supply of capital inputs would probably place a lower bound on  $e$  at .5.

We can summarize our assumptions about  $M$ ,  $k$ ,  $\sigma$ , and  $e$  as follows:

$$(2) \quad M \approx 1 \quad k \approx .3 \quad 0 \leq \sigma \leq 1 \quad .5 \leq e \leq 1$$

By allowing the values for  $\sigma$  and  $e$  to vary within their ranges in Equation (1) we can determine the sensitivity of these variables to  $\lambda$  and derive representative values for  $\lambda$ :

(3)

$M = 1$			
$k = .3$	$e = .5$	$e = .75$	$e = 1.0$
$\sigma = 0$	.12	.16	.18
$\sigma = .5$	.61	.62	.63
$\sigma = .75$	.82	<span style="border: 1px solid black;">.82</span>	.82
$\sigma = 1$	1.0	1.0	1.0

If we assume that  $\sigma = e = .75$ , then  $\lambda$ , the derived elasticity of demand for office space, equals .82. Note that with  $M = 1$ ,  $k = .3$ , and  $\sigma = .75$ ,  $\lambda$  is insensitive to  $e$ . Note further that  $\lambda$  is sensitive to  $\sigma$ , but with  $M = 1$ ,  $k = .3$ , and  $e = .75$ , marginal changes in  $\sigma$  yield only marginal changes in  $\lambda$ . Hence, insofar as our estimate of  $\sigma$  is approximately correct, our estimate for  $\lambda$  will also be correct.

We can now estimate the gross effect of flat conductor cable utilization on the demand for office construction (both new and retrofit). The construction effect will increase office construction by .0494 times .82, or by 4.1%. Presumably, the increase in electrician man-hours due to the construction effect will be proportional.

#### IV. The Outlet Effect

The outlet effect can be estimated by multiplying the percentage reduction in wiring costs from the application of flat conductor cable by the price elasticity of (derived) demand for electrification.

We know from Sections II and III that the total cost of wiring was reduced from \$455 per desk to \$314 per desk, which represents a 44.9% decrease in wiring costs.

The demand for electrification is a derived demand. Firms demand electrification as an input in the production of office space (office construction), which itself is demanded as an input in the provision of final products. The demand for electrification is derived from the demand for office space. Unfortunately, the economic literature does not contain estimates of the elasticity of (derived) demand for electrification. However, by applying Equation (1) in a slightly modified form,

$$(4) \lambda' = \frac{\sigma'(\lambda' + e') + k'e'(\lambda' - \sigma')}{\lambda' + e' - k'(\lambda' - \sigma')} = \frac{\sigma'(\lambda + e') + k'e'(\lambda - \sigma')}{\lambda + e' - k'(\lambda - \sigma')}$$

where  $\lambda'$  (equals  $\lambda$ ) is the price elasticity of demand for office space;  $k$  is the share of total costs of office construction represented by conventional wiring;  $\sigma'$  is the elasticity of (technical) substitution of electrical inputs for all other (aggregate) inputs in the construction of office space; and  $e'$  is the (aggregate) elasticity of supply for all other (non-electrification) construction inputs.

We know from Section III that  $M' \cdot \lambda = .82$  and that  $k'$ , the percentage of total construction costs represented by conventional wiring, is .11. The nature of office space is such that its production involves relatively fixed proportions insofar as each room (and desk) requires some electrification, but some variability regarding number of outlets, etc., is also available. Hence, we estimate  $\sigma'$  to be approximately .5. The elasticity of supply of non-electrification construction inputs is also dominated by labor and capital inputs. However, the relevant labor supply is no longer the U.S. labor market, but just the supply of construction workers, which can attract the remainder of the U.S. labor market. Hence, the supply of construction workers is relatively elastic as is the supply of capital inputs for construction. We thus believe  $e'$  is relatively elastic, and estimate it to be approximately 1.2.

By substituting the above values,  $M' \cdot \lambda = .82$ ,  $k' = .11$ ,  $\sigma' = .5$ , and  $e' = 1.2$  into Equation (4), we find that  $\lambda'$ , the price elasticity of (derived) demand for electrification equals .53. We can now estimate the gross outlet effect of flat conductor cable as an increase in electrification per office of .449 times .53, or 23.8%. We again presume that the increase in electrician man-hours due to the outlet effect will be proportional.

V. The Total Effect of Flat Conductor Cable

The total effect of flat conductor cable on the demand for electricians in office construction is a combination of the process effect, the construction effect, and the outlet effect, but so as to avoid double counting.

From Section II, we know that the process effect does not change the demand for electricians in office construction. From Section IV, we estimated that the outlet effect will increase the usage of electricians by 23.8%. This will increase the cost of office construction by .238 times .11, or by 2.6% (since the cost increase equals the increase in wiring activity and cost multiplied by the percentage of office construction cost accounted for wiring). The cost savings per office attributed to flat conductor cable, taking into account the increased electrification per building, is now 4.94% minus 2.6%, or a net saving of 2.34%. Hence, the net construction effect is .82 times .0234, or 1.9%. The total increase is electrician's wiring time attributable to flat conductor cable is thus [(1) times (1.238) times (1.019)] minus 1, or a 26% increase in electrician's time. This is reduced somewhat if electricians participate in the placement of underfloor ductwork, since a substantial portion of ductwork is eliminated when flat conductor cable is used.

### 5.1.3 Summary of FCC Project Participation

#### URBAN CONSTRUCTION AND SAFETY PROJECT

##### Technology + Economics, Inc.

- Advocate project participation to industry
- Assure that system as developed is user/market responsive
- Coordinate hardware development: assure hardware delivery, finances
- Oversee drafting of system specs and NEC proposal

#### GOVERNMENT PARTICIPATION

##### NASA Headquarters

Bill Smith

Andrew Sears

- Overall direction of NASA FCC involvement

##### Johnson Space Center -- Urban Systems Project Office

Carey Lively

Ted Hays

- Financial support for BB<sup>1</sup> and UC<sup>2</sup> systems
- Letters of endorsement to UL
- Advocacy of NASA/TU interests

##### Marshall Space Flight Center

Jim Hankins

Jim Cardin

- Developer of FCC building wiring systems
- Technical responsibility for BB system project
- Ongoing technical support for UC system implementation project

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<sup>1</sup>"BB" = baseboard

<sup>2</sup>"UC" = undercarpet

General Services Administration - Public Building Service

Charles C. Law

James King

Paul Gill

- User of UC system
- Potential supporter of UL fact-finding
- Demonstration installations

Department of Housing and Urban Development -  
Field Operations

Pierre Brosseau

- Potential user and supporter of BB system

Department of Housing and Urban Development -  
Policy Development and Research

Jim McCollom

- Funding for NBS investigation of Romex and FCC

National Bureau of Standards -  
Center for Building Technology

Lawrence Gallowin

William Meese

- Conduct HUD/PDR-funded study on Romex and FCC
  - laboratory studies of electrical and fire safety
  - performance standards for FCC
  - coordination with UL BB system study

New York State Urban Development Corporation (inactive)

David Pellish

Harry Wolcott

- Initial advocate of surface-mounted wiring for masonry or concrete multi-family residential construction
- Prototype installation
- Corporation financial trouble curtailed involvement

City of Baltimore

Tom Golden (GSFC)

- Possible user of BB system for renovation



New York City Housing Authority

Eric Nadel

- Possible user of BB system

INDUSTRY

AMP, Inc.

Jim Fleishhacker

Chuck Schaal

Ed Bunnell

August Kastel

Joseph Neigh

- Connectors, splices, taps, terminations for UL submission and marketing
- UC telephone system components
- FCC system cost information
- Draft system installation instructions for UL
- Financial support for UL fact-finding

Bell Telephone Labs - Whippany, New York

Len Sessler

- General technical advice
- Advice on Code proposal

Bell Telephone Labs

D.P. Woodward

- Supplementary testing of UC system components

Brand-Rex Corporation

Irving Dwyer

Edward Brandeau

Joseph Marshall

Ken Brownell

- Cable for UL submission
- Development of alternate cable constructions and materials
- Cable testing
- Financial support for UC fact-finding

Collins and Aikman, Inc.

Lester Votava

- Carpet for UC fact-finding
- Technical assistance on carpet/UC system interface problems
- Financial support for UC fact-finding

DuPont

Cutter Palmer

- Technical advice on insulation specifications
- Assist UL and NEC efforts
- Financial support for fact-finding
- Manufacture insulating material

General Electric (delayed involvement)

Tom Swetman

- Potential manufacturer of UC system components

Hi-Temp Wires

Bill Stant

Bill Frogner

- Possible participation in BB system UL/NEC effort
- Possible technical assistance in cable development
- Possible marketer of cable

Lamotite Products, Inc.

Robert Jackson

Robert Underhill

James Powers

- Specify and provide foil and non-metallic underlay for UC system

Leviton

Saul Rosenbaum

- Develop GFCI/compensator systems
  - in receptacles for BB system
  - in round-to-flat junction boxes for UC and BB system
- Potential developer of baseboard system
- Likely supporter of UC system project and UC hardware developer

Millikan, Inc.

Tony Williams

James Hester

- Carpet for UL fact-finding
- Technical assistance on carpet/UC system interface problems
- Financial support for UC fact-finding

The Montgomery Company

James Devine

- Wire manufacturer
- Possible assistance in cable product engineering

Parlex Corp.

Chuck Surat

- Cable for UL submission
- Cable testing
- Market cable
- Nominal support for fact-finding

Raychem Corp.

- Potential technical assistance and participation in cable development

Thomas and Betts, Inc.

Ed Eldridge

David Beers

Manny Bromberg

Ray Piasecki

- Original request letter to UL for fact-finding study drafted
- Develop foil connecting system and receptacle/doghouse for UC study at UL
- Technical coordination with UL during fact-finding
- Possible manufacture of cable through Ainsley subsidiary

- Draft Code proposal
- Financial support for fact-finding
- Ultimately intends to develop complete UC system for marketing

Underwriters' Laboratories

H.E. Reymers  
 Dick Gloyston  
 Ed Coffey  
 Ed Krawiec

- Develop testing program and issue fact-finding reports on FCC systems
- Advice in drafting Code proposal

Walker-Parkersburg, Inc.

Mr. Flashbarth

- Possible UC project participant

Western Electric - Engineering Research Center

Jack Balde

- Critical catalyst - large potential user, knowledgeable, farsighted
- Presentation of relative economics of FCC vs. conventional wiring
- Assist development of industry participation
- Assist development of system specifications
- Technical advice on conduct of UL testing
- Facilitate power/telephone system interface
- Financial support for fact-finding

Western Electric - Plant Design and Construction

Harvey Mumford

- Potential user of UC system; system specifier

In addition to this listing, there have been numerous inquiries about FCC made to Marshall Space Flight Center. A list of these contacts are available from Jim Hankins of Marshall.



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127 Mount Auburn Street  
Cambridge, Massachusetts 02138  
617 491-1500

## APPENDIX 5.2

### 5.2.1

POTENTIAL FOR THE APPLICATION OF  
ADVANCED TECHNOLOGY  
TO FLOOD ELEVATION STUDIES  
OF THE FLOOD INSURANCE ADMINISTRATION

September 18, 1975

Prepared By:

James R. Simpson

POTENTIAL FOR THE APPLICATION OF ADVANCED TECHNOLOGY TO  
FLOOD ELEVATION STUDIES OF THE FLOOD INSURANCE ADMINISTRATION

This analysis of the methods used by the U.S. Geological Survey (USGS), the U.S. Army Corps of Engineers (C of E) and the National Oceanic & Atmospheric Administration (NOAA), in conducting Flood Insurance Studies for the Flood Insurance Administration (HUD), was carried out through telephone interviews with officials in these agencies. (Appendix I) Particular emphasis has been given to the cost of various elements of such studies and to the potential for reducing these costs by the application of advanced technology.

Procedure For Conducting a Flood Insurance Study

A Flood Insurance Study, among other things, results in a map showing that portion of the community studied which will be flooded by a 100-year and a 500-year flood, together with the elevations of the 100-year flood. Also shown is the delineation of a floodway which is that channel of the stream required to carry and discharge a 100-year flood without undue rise in the flood water level.

In very simplified terms, developing this map for a riverine area, requires obtaining numerous cross section surveys of the stream being studied, estimating roughness coefficients of the stream bed, and determining the peak discharges for various flood frequencies. Several computer programs are available which will convert this information into

100- and 500-year flood profiles which are then plotted on a contour map. This is subsequently used to produce the Flood Insurance Rate Map. The floodway delineation also is obtained from the computer printout and, modified with professional judgment, is plotted on the same map. Frequently, the flood profile and floodway must be correlated with earlier studies in the vicinity and coordinated with local officials so that some recomputation (trial and error work) is necessary.

#### Methods of Cost Estimating

The methods for time and cost estimating used by the several Federal agencies conducting Flood Insurance Studies for the FIA vary somewhat. The principal variation is evident between the C of E and the USGS.

In making cost estimates, the USGS tends to break the work into task categories in the order in which a study is undertaken. (Appendix II) For instance, the first task category is Reconnaissance, and the last is Report Writing. Each of these major tasks lists subtasks which also tend to follow the sequence in which the task would be accomplished, and which serve to organize the thinking of the engineer making the cost estimate.

The C of E tends to estimate costs using a somewhat different breakdown of cost categories. First, the work is conceived as being separated into Field Work and Office Work. Field Work includes Reconnaissance and Surveying. Office Work is separated into Technical Analysis and Drafting & Report Writing. Technical Analysis is further subdivided into Hydrology and Hydraulics. An outline of the C of E concept of categories appears to be somewhat as set forth in Appendix III.

Regardless of the methods for categorizing costs for purposes of

estimating, the majority of offices in both organizations in effect seem to follow similar processes. For instance, the basis for estimating survey costs is to determine the number and length of cross sections to be surveyed and the number and kind of crossings (bridges, culverts, etc.) to be measured. Map preparation and drafting costs are estimated on the size of the area to be covered and the number of plates which will be required in the final report. These tasks are then costed on a per-unit basis; for instance, cost per cross section for surveying and cost per plate for drafting, map preparation and reproduction. Other tasks are costed by both agencies on an estimate of the number of man-days required. Thus, both agencies essentially consider the same basic cost categories in arriving at a final cost estimate. Therefore, all things being equal, there should be no significant differences in cost estimates prepared by the two agencies.

#### Reasons for Cost Variations

As a practical matter, however, all things are seldom equal in comparing several Flood Insurance Studies. Therefore, there is ample opportunity for wide variations in the cost of one study and another. These occur mainly as a result of two types of variations in projects: (1) differences in the size and/or complexity of projects and (2) differences in the extent to which data required for the study are already existing and available.

In addition to these reasons for variation, within each agency there may be cost differences for specific items caused by the way each engineer perceives and carries out his task. For instance, one may strive for a



higher level of accuracy than another and feel, for instance, that a larger number of cross sections are needed. Also, some engineers are quicker than others in perceiving solutions to correlation and coordination problems.

#### Discussion of Items of Cost

Most of the engineers interviewed agreed that surveying ordinarily represents the largest single item of cost on a project. Costs from 1/3 to nearly 1/2 the total project costs were cited. So that a study covering an area where a substantial part of the basic survey data are already available, would experience relatively low project costs. Photogrammetry, which seems to be used increasingly for surveying, particularly on the larger streams, reduces this cost somewhat but not enough to reduce it to an insignificant amount.

While a majority of those interviewed did not consider drafting to be a major cost item, a few engineers seemed to feel that drafting, map reproduction, printing, etc., also represented a major cost item, especially on the larger projects. Studies involving a few hundred plates for the final report are cited as examples of situations where such costs are important, and may involve 1/3 of the total project costs. Again, the extent to which usable maps are available greatly effects the cost of map preparation. Where good maps are available, which require a minimum of work to make them ready for use in the flood study, the cost of this item will be materially reduced.

Analytical work -- discharge computations, computer runs, profile analysis and floodway determinations -- seem to represent a small part

of the total cost of a project. Generally, the major cost item in this category is related to the work associated with the computer program. This includes preparing input data, analyzing the printout, readjusting the input data, and rerunning the program until the results fit historic data and other previously conducted studies. Complex projects involving several earlier studies on contiguous areas can cause substantial increase in the cost of this work. These costs are magnified in those few cases where the engineer must travel some distance to gain access to a computer terminal. Of those interviewed, no one had sufficient experience with more than one computer program to express an opinion on cost variations. One engineer reported he had modified the USGS program to allow rerunning portions and thus had saved time.

Several engineers interviewed felt that the proportion of total project cost represented by analytical work, floodway determination in particular, is increasing markedly, because of the recent increased emphasis on local community cooperation. Meetings, conferences, and coordination discussions with local officials must be carried out by the professional people working on the project, so that increased costs for this activity will likely be large. For the larger communities, this work can be substantial.

#### Tidal Flood Studies

Where tidal flooding is being studied, cost estimates for the several categories vary somewhat from riverine flooding. Surveying costs usually are not high since it is limited only to that necessary to update existing maps. On the other hand, the cost of analytical work usually is much

higher since the computer program is much more sophisticated and requires a longer time to run. Analytical work probably accounts for 1/3 of the cost of a typical tidal flood study, with the computer time being a large part.

In the instances where a Flood Insurance Study covers an area involving both riverine and tidal flooding, costs are increased further since both computer programs must be run and rerun to determine which is the greater risk.

#### Relationship of Estimated and Actual Costs

There was substantial difference of opinion on the extent to which actual costs incurred on a project conform with the estimates. At least one official conveyed the impression that the estimated cost is assumed to be the actual cost and that no effort is made to determine actual costs. Others interviewed seemed to feel that actual cost records are not reliable since the accounting procedures used do not readily permit careful cost allocations to various projects. Several offices reported that in the case of surveying costs, the estimate is assumed to be the actual cost.

#### HUD's Time & Cost Estimate Form

Most of those interviewed, had used HUD Form 1500.2 for cost estimating purposes and had experienced difficulty in knowing exactly what work items should be included under each category. Also, most pointed out that the form does not adequately accommodate their needs in cost estimating, now that HUD is emphasizing the use of "approximate

methods" for studying parts of areas and "detailed methods" for studying other parts. For these reasons, a study of cost estimates submitted on this form could be misleading.

Correction of these two deficiencies should result in the form being useful for cost estimating purposes. However, additional information on conditions which could increase or decrease costs on a specific project might be needed to make any critical review of an estimate.

#### Opportunities for Cost Reduction

A very large number of flood studies will be required for the Flood Insurance Administration to carry out its responsibilities. Thus, any cost reductions which can be accomplished in a study could have enormous benefit over a period of time. Opportunities for cost reduction by the application of advanced technology are offered, such as, surveying, analysis, and drafting.

List of Officials Interviewed

Nick Barbieri	Corps of Engineers	Philadelphia District, Pa.
Ken Darmer	U.S. Geological Survey	Albany, N.Y.
Hank Edwards	Corps of Engineers	Pittsburgh, Pa.
Chuck Farnham	Corps of Engineers	Rock Island District, Ill.
Bill Gannon	U.S. Geological Survey	Madison, Wisc.
Ed Kennedy	U.S. Geological Survey	Reston, Va.
Shelton McKeever Charlie Malphras	Corps of Engineers	Savannah, Ga.
Jerry Peterson	Corps of Engineers	Washington, D.C.
Everett Ramey	National Oceanic & Atmospheric Administra- tion	Washington, D.C.
Dave Richards	U.S. Geological Survey	Wichita, Kansas
Ed Sizemore	Corps of Engineers	Sacramento, Calif.

## Work Schedule For Hypothetical Flood Insurance Study

### Reconnaissance

- Map study of area
- Drive to and from
- Interview officials
- Get historic flood data
- Obtain other agency data
- Select cross section sites
- Prepare work plan
- Make time and cost estimates

### Surveying (3 man party)

- Drive to and from
- Run control levels
- Run cross sections
- Locate sections on map
- Prepare punched cards

### Discharge Computations

- Select best model
- Run drainage areas
- Run river distances
- Compute basin slope
- Compute area lakes and ponds
- Compute other parameters
- Compute 10, 25, 100, 500 Q
- Tabulate results

### Map Preparation

- Obtain best work map
- Obtain best presentation map
- Select final scale and placement
- Obtain final base map segments
- Prepare profile sheets, plot streambed

### Computer Run

- Prepare all input data
- Travel to and from terminal
- Plot profiles, justify anomalies
- Scrutinize floodway output
- Reconcile all apparent problems

Work Schedule For Hypothetical Flood Insurance Study (cont'd)

Profile Analysis

Select reaches  
Compute FHF  
Group FHF  
Tabulate FHF

Work Map Analysis

Plot 100-500 outlines  
Plot floodway cross sections  
Add floodway outline  
Plot base-flood elevation lines  
Accent lines for transfer

Report

Write

District Review

Report  
Map  
Revise  
Assemble

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C of E BREAKDOWN FOR COST ESTIMATING  
FLOOD INSURANCE STUDIES (Suggestive)

Field Work

Reconnaissance

Surveying

Office Work

Analysis

Hydrology (Discharge Computations)

Hydraulics

Computer Run

Profile Analysis

Drafting and Report Writing

Map Preparation

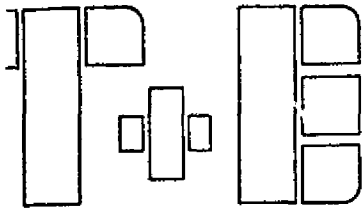
Work Map Analysis

Drafting

Report Writing

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## APPENDIX 5.2.2

Technology + Economics, Inc.  
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### A REPORT ON A FLOOD INSURANCE STUDY MEETING

#### Involving:

- Federal Insurance Administration  
Department of Housing & Urban Development
- United States Geological Survey
- National Aeronautics and Space Administration
- Technology+Economics, Inc.

5 December 1975



## Table of Contents

	Page
1.0 <u>Agenda</u> . . . . .	1
2.0 <u>Attendees</u> . . . . .	3
3.0 <u>Minutes</u> . . . . .	4
4.0 <u>Conclusions and Followup</u> . . . . .	11
5.0 <u>Background</u> . . . . .	13



## 1.0 Agenda

### FLOOD INSURANCE STUDY MEETING

- Federal Insurance Administration (FIA)
- National Aeronautics and Space Administration (NASA)
- United States Geological Survey (USGS)

Dept. of Housing and Urban Development, 7th & D, SW  
Room 4100  
Washington, DC

5 December 1975, 9:30am

### OBJECTIVES

1. To acquaint NASA representatives with the context, nature and procedures of FIA's Flood Insurance Studies, and to delineate the problems that FIA faces in these studies for which NASA may be able to offer technological assistance.
2. To acquaint FIA and USGS representatives with the technological resources that NASA may be able to apply towards flood insurance problems.
3. To explore possible ongoing arrangements by which NASA and FIA can work together in improving flood insurance study techniques and procedures.

### PROPOSED AGENDA

- |   |       |
|---|-------|
| 1. Introductions and introductory Remarks -<br>James R. Simpson, Technology + Economics, Inc. | 9:30  |
| 2. Overview of FIA's Flood Insurance Study Programs -<br>Mel Crompton, FIA                    | 9:50  |
| 3. Coffee   | 10:20 |
| 4. Flood Insurance Study Procedures and Requirements -<br>Edward Kennedy, USGS                | 10:30 |
| 5. Presentations of NASA Approaches and Technological Resources:                              |       |
| a. Albert Rango, Goddard Space Flight Center -  | 11:00 |
| Discussion -  | 11:30 |
| 6. Lunch  | 12:00 |



7. NASA Presentations, continued
  - b. Richard Green, Nevon Bryant, Jet Propulsion Lab - 12:45  
Discussion - 1:15
  - c. Murray Felcher, Office of Applications, NASA HQ - 1:40  
Discussion - 2:10
8. Exploration of NASA/FIA Working Arrangements: 2:30  
Discussion -
9. Concluding Remarks - James Simpson, T+E - 3:00



## 2.0 Attendees

<u>Name</u>	<u>Organization</u>	<u>Phone</u>
Fred C. Billingsley	Earth Observations, JPL	213-(FTS)792-5677
Nevin A. Bryant	Jet Propulsion Lab, Cal Tech	213-354-7236
Curt Chandler	FIA, Washington, D.C.	FTS 792-7236
Mel Crompton	FIA, Washington, D.C.	202-426-1891
George W. Edelen	USGS - Reston, Va.	202-426-1460
Richard H. Green	Civil Systems Prog. Ofc., JPL, Cal Tech	703-860-6804
Peter Hogarth	T+E, Cambridge, Mass.	213-354-6703
E.J. Kennedy	USGS	FTS 792-6703
Dick Krimm	FIA, Washington, D.C.	617-491-1500
John Leo	FIA, Washington, D.C.	703-860-6804
Theodore M. Levin	FIA, Washington, D.C.	202-755-5581
Charles A. Lindsay	FIA, Washington, D.C.	202-755-5585
William R. Locke	FIA, Washington, D.C.	202-755-5587
Brian R. Mrazik	FIA, Washington, D.C.	202-755-6776
Albert Rango	NASA, Goddard S.F.C.	202-755-6779
Jim Simpson	T+E, Annandale, Va.	301-982-5480
Frank Y. Tsai	FIA, Washington, D.C.	703-256-0466
George Windsor	HUD, Policy Dev't & Research, Washington, D.C.	202-755-6776



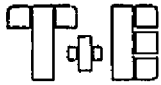
### 3.0 Minutes

The meeting started with an introductory talk by Richard Krimm, Assistant Administrator for Flood Insurance Studies. Mr. Krimm described the reasons for which Flood Insurance Studies are undertaken, i.e., for setting actuarial rates for new structures, for defining flood insurance rates for existing structures, and for enabling communities to develop comprehensive floodplain plans and measures. He then outlined the two main components of flood studies, namely, the initial flood hazard boundary maps, and the subsequent detailed studies, and stressed the need for accuracy in all phases of the studies.

Jim Simpson, senior scientist at T+E, then made introductory remarks related to the plan for this meeting and its hoped-for output.

Mel Crompton of FIA then continued in more detail the introduction to the program. He described in particular the two phases of the program -- the "emergency phase" in which flood hazard boundary maps are prepared, and the "regular program" in which detailed studies are made. The Flood Hazard Boundary Maps are drawn on the basis of existing maps and information, without original field work. The majority of these maps are already completed -- 17,000 out of the total of about 20,000. Two contractors are carrying out this work. The detailed studies have two main outputs: The first is a flood hazard rate map which delineates flood insurance rates within the flood hazard zone. The second and more important output is a detailed study which will aid the community in appropriate flood plan planning measures.

Ed Kennedy of USGS described in detail the process of producing a flood insurance rate map and a flood insurance study. This portion of the meeting overlaps with a background paper that Jim Simpson of Technology + Economics had previously prepared. These remarks are combined with Mr. Simpson's



original paper in Section 4.0 of this report to make a single, detailed background presentation.

In the discussion following Mr. Kennedy's presentation, some additional comments were made, as follows:

- Tidal flooding, as opposed to riverine flooding, is a particularly difficult aspect of flood insurance studies. While NASA inputs in this area could certainly be of value, the FIA participants in the present meeting are not specifically involved in this area and cannot discuss it in detail.
- Erosion, mudflow, and landslide are additional aspects of FIA's range of concern that are appropriate to NASA involvements, but they are not as important or tractable as riverine flooding studies.
- FIA has not systematically addressed the effects of urbanization and development on runoff, topography and floodways, although these effects are recognized as important by both NASA and FIA.
- FIA has not addressed the problem of compliance -- i.e., seeing that development patterns are in fact responsive to known flood hazards. Since 22,000 communities need to be monitored, this is a large problem, and implies approaches other than ground-based inspection procedures.

Albert Rango of Goddard Space Flight Center made the next presentation. His work has been based on the differential reflectance of infrared wavelengths by different land features, as seen by Landsat imagery. This work has involved photo interpretation at a 1:100,000 scale, and interpretation and digitization at 1:62,500 and 1:24,000 scales. The resolution presently attainable via Landsat imagery is in the range of 68-80 meters; if Landsat IV is approved, resolution will improve to 30-40 meters.



Within these limits of resolution it is possible to delineate a floodplain both by looking at an actual flood and by looking at natural features.

Mr. Rango first presented Landsat images and their interpretations for the Mississippi River basin floods of Spring, 1973. These floods approximated the "100-year" flood level, and the Landsat-derived imagery corresponded closely with the 100-year contours of USGS maps.

Next, he presented a predictive comparison of the 100-year floodlines delineated by ground surveys and by Landsat sensing. A .92 correlation was found between the distances at various points from the stream center to the floodlines for the two methods. The source of the deviations is not clear. It may be in part due to flaws in the groundwork, since there have been cases where remotely-imaged floods have not coincided with ground-surveyed floodlines for clear physical reasons.

The coincidence of the 100-year floodlines and the floodplain according to remote sensing has no physical reason that is currently apparent. What is being imaged is the past history of the floodplain area.

The flood boundaries determined by this predictive work are based mainly on presence of soil water, types of vegetation, and natural and artificial levees. The process of interpreting the imagery is built upon attempts to arrive at a reliable floodplain "signature". It is not yet known how reliable the "signature" is as a floodplain delineator; further verification work will be needed.

Mr. Rango summarized his conception of what his work may be able to offer FIA as follows:

1. Early planning information and development guidelines, particularly where formal ground surveys have not been made.





2. Delineation of actual floods to get firm boundaries, with the possibility of extrapolating these boundaries.
3. Checking discrepancies of floodlines in already surveyed areas, such as are caused by new development.
4. Monitoring adherence of development to Flood Insurance Study guidelines.
5. Damage estimates.
6. Generation of improved stormflow volumes.

In the discussion that followed, Ed Kennedy and Mel Crompton were primarily interested in applications of this methodology to the "emergency" phase of the program -- the delineation of flood hazard boundaries. Here, fineness of resolution is not a major concern. The costs of remote sensing methods are comparable to present FIA methods -- about \$4.30 per square km, or \$600 per quad. This cost would be lower for higher volume applications.

Cost comparisons, however, do not indicate one major issue, which is that present methods are not applicable in many remaining areas. Although only 3000 areas out of the total of 20,000 remain to be surveyed for flood hazard delineation, these remaining areas are on the whole larger, and have poorer maps or no maps at all. In parts of Nevada, for example, remote imagery may in fact be the only way of completing the studies which have so far been proposed.

After lunch, three representatives from the Jet Propulsion Laboratory at Pasadena, California made a presentation. These representatives were:

- Richard Green, of the Civil Systems Program Office,
- Fred Billingsley, Coordinator of the Earth Observations Program, and
- Nevon Bryant, involved in a task effort in land use planning.



Nevon Bryant gave the bulk of the presentation. His subject was the general area of the "Geographic Information Systems" that have been developed over the last two years to store, retrieve, process, and display geographic and land use information. He described the basic operations that the system at JPL is capable of performing. They are as follows:

1. Two images, or maps, or an image and a map, can be combined into a single stored image. A map can be scanned and turned into a computer tape by means of a microdensitometer. Registration--that is, the alignment of a new map or image with existing stored material, is accomplished by means of a visual process from which an algorithm for the computer is derived. Thus, one does not have to manually map together the coordinates of each pair of points on the images; it is necessary to lock the images together at only one point.
2. Given an image stored on magnetic tape, a map can be generated of any part of that image, such as a particular census tract.
3. Thematic mapping is readily accomplished, in which one or more selected land use classifications can be printed out, without unneeded background information. Two or more classifications can be imaged distinctly from each other (i.e., two or more colors) or can be collapsed together.
4. Land use changes over time can be found. The old and the new image are processed together and a composite image is printed. Where the old and new image are the same, the composite image is also the same. At places where a land use change has taken place, and the old and new images are different, the computer prints

T-E

nothing. The change areas appear as easily visible blank patches on the composite map. This procedure has been used to keep track of building permits issued by cities, and could also be used to monitor floodplain development.

The JPL group's image processing capabilities are valuable insofar as the input data is appropriate and of good quality. Inputs for high-resolution land classification are available. High-altitude aircraft imagery offers resolution down to 7 1/2-meter squares (i.e., 50 square meter areas). This degree of resolution appears to be within the requirements for detailed Flood Insurance Study work. The additional point was made that multispectral classification is a judgmental process which varies in quality. More subtle classifications are possible than what are being used now.

Following this presentation, the possible applications of geographic information system technology to Flood Insurance Studies were discussed. The following major types of applications emerged:

1. "Emergency phase" flood hazard boundary maps could be processed fully automatically using this system.
2. Given a contour map of sufficiently good quality, one could obtain flood areas, which could then be scribed onto the map.



3. Once sufficient confidence is achieved in multispectral analyses as floodplain indicators, they can be mapped together with conventional contour maps and correlated.
4. "Change data" can be quickly displayed, to monitor compliance of new development with floodplain management guidelines. Enforcement monitoring with conventional ground procedures is essentially beyond FIA's resources.

As part of the general discussion, it was proposed by Ed Kennedy that it may be possible to use NASA technology in place of the step-backwater modelling procedure that is currently used. The flood plain boundaries, which may be accurately determinable by remote sensing, and the cross-sections may in themselves constitute the necessary basis for a direct output of a Flood Insurance Study. The feasibility of this approach may be appropriate for joint NASA/FIA exploration.



#### 4.0 Conclusions and Followup

Briefly stated, the primary conclusions of the meeting are as follows:

1. Remote sensing, multispectral analysis, and automated image processing are likely to be useful for the 3000 Flood Hazard Boundary Maps that remain to be delineated. They could comprise the dominant approach for this work.
2. Applications of NASA technology could eliminate the need for the present step-backwater analysis in detailed Flood Insurance Studies and would represent a major efficiency in the process. Multispectral analysis may improve the reliability of flood boundary data sufficiently to allow this innovation.
3. As a step to refining and utilizing remote sensing and multispectral analysis in both 1 and 2 above, the accuracy and reliability of these techniques need to be carefully studied as well as the discrepancies noted between NASA's floodplain delineations and the conventional delineations.
4. NASA image processing systems can cut labor costs by combining and correlating Flood Insurance Study inputs and automatically printing out the resultant rate zone maps.
5. NASA remote sensing and image processing can aid in early planning and development information; in floodplain development monitoring; in comparing floodlines with actual floods; and in damage assessment.

The immediate followup steps that were agreed upon are as follows:

1. Al Rango and if possible JPL will meet in January with FIA's two contractors to investigate ways



of improving and expediting production of the remaining flood hazard boundary maps.

2. By early to mid January, the JPL group will produce a concept paper outlining possible applications of their technology and estimating the costs for a feasibility study. T+E Inc. will assist this concept paper by delineating and structuring into "modules" the range of Flood Insurance Study procedures and methodologies.
3. Based on the outcome of the above two items, a further general NASA/FIA meeting will probably be appropriate to further delineate the range of possible NASA/FIA cooperation. NASA groups who were not able to attend due to the short notice could attend this next meeting.



## POSSIBLE NASA INPUTS TO FIA'S FLOOD INSURANCE STUDY PROCEDURES

The purpose of this paper is to conceptualize FIA's present Flood Insurance Study procedures as a set of discrete elements, or "modules," and then indicate possible ways of altering, bypassing, supplementing, and combining these modules through applications of NASA technology.

The bulk of what is presented has to do with the process of obtaining detailed Flood Insurance Rate Maps. Emphasis is placed here because generating these maps is a particularly complex and expensive part of FIA's activities, and the part where analysis is most needed. The latter pages of the paper are devoted to this subject.

Flood Insurance Rate Maps, however, are certainly not the only important areas where NASA may be able to offer assistance. Three others are easily identifiable and should be mentioned at least in passing. They are:

- Emergency Phase Flood Hazard Boundary Maps
- Monitoring of Flood Plain Development
- Flood Damage Assessment

Flood Hazard Boundary Maps serve the general purpose of guiding development in flood-prone areas. They are of particular importance to FIA because of the pressure they are under to get them completed quickly. They do not involve original survey work, but rather build on existing maps and data. FIA wants to achieve



cost and time reductions for the 3000 remaining maps. Also, in some cases, they will have the additional problem that good existing maps are not available.

Monitoring of floodplain development to ensure compliance with insurance requirements is a further need that FIA cannot address with its present resources. Flood damage assessment is another requirement for which ground-based techniques are difficult and excessively slow when quick disaster aid is needed.

All three of these areas imply use of geographic information system techniques and land classification via remote sensing.

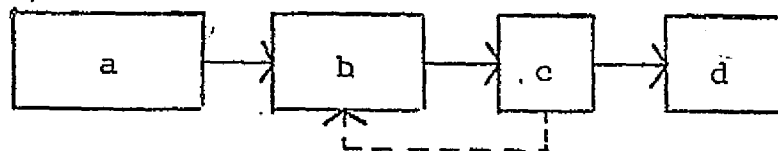
In the case of flood hazard boundary delineation, remote sensing has obvious potential as the dominant approach for areas where adequate maps do not exist. It may also be a valuable supplement for other areas where maps do exist: Frequently these maps are outdated and do not reflect the effects of more recent development that show up clearly with remote sensing. Geographic information system technology may also result in substantial time and labor savings. This would be particularly the case where multiple inputs need to be mapped together.

Floodplain development and flood damage are both readily visible via high altitude and satellite sensing. The resulting images can be readily processed via geographic information system techniques to detect and locate "change data" -- year-to-year floodplain development changes, and before-flood/during-flood changes.





Turning now to the Flood Insurance Rate Map procedures, a diagrammatic approach suggests itself as a way to depict the modules out of which Flood Insurance Studies are built, and the possible alterations and manipulations of these modules. The conventional Flood Insurance Study is comprised of four primary modules. The first (a in the diagram below) is the process of obtaining numerous, detailed cross-sections of the stream. The second (b) is the "step-backwater" hydraulic analysis that develops flood contours from the cross-section data and gauging-station data for peak flows. The third module (c) is the correlation of the analytical results with other types of data, previous studies, and common sense. This correlation process may exist in an iterative relationship with the hydraulic analysis, until differences are resolved or at least understood. Fourth, there is the step of mapmaking and reproduction, both to make a large study map and to make published, printed maps. The graphic representation is as follows:



The size of the modules is intended to depict their relative importance as cost and time items.

THE

The following three pages present six modifications of the "baseline" study. Possible NASA technologies are represented now by modules that substitute for and juxtapose with the original modules. The "NASA modules" are marked with different types of hatchmarks according to the generic type of application they represent. The first of the three pages contains the legend that explains these hatchmarks. The five modifications are presented without any attempt at judging their real technical feasibility. This judgment will have in each case to be made by the technical actors involved. It is hoped, however, that this conceptualization will aid in defining possible opportunities.

LEGEND



Baseline situation: no NASA technological application.



Geographic information system technique.

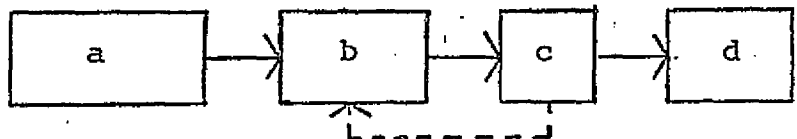


Land classification technique based on remote imagery.



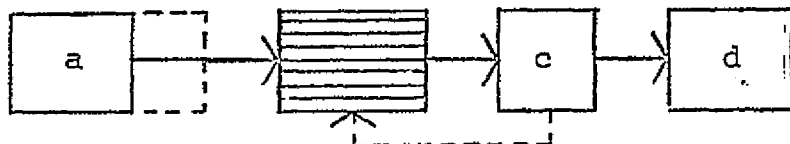
New analytical method: either to perform an existing task in a new way, or to perform a new task.

0)



- 0) Baseline:
- a. Cross-section surveys
  - b. Step-backwater analysis
  - c. Correlation with existing information
  - d. Mapmaking and reproduction

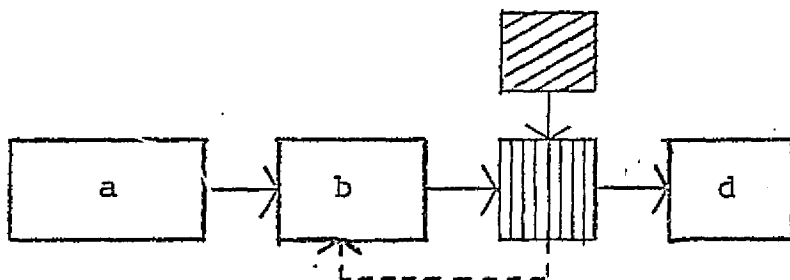
1)



- 1) Improved analytical method to reduce input data needs.

1) Primary goal is to reduce or eliminate need for original cross-sectional surveys -- usually the largest cost item in Flood Insurance Study

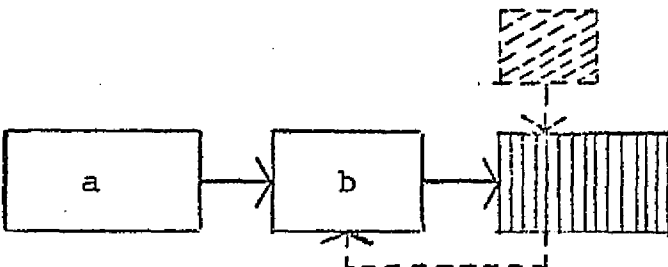
2)



- 2) Correlation of conventional analysis with land classification maps derived from remote imagery. Use of geographic information system techniques implied.

2) Reliability and accuracy of remote techniques not known in comparison with conventional methods. Best used in correlation with conventional data. Increased sophistication of land classification techniques may be needed

3)



- 3) Automated mapping of analytic output into final map product. Use of remote land classification techniques in correlation with conventional approach is implied.

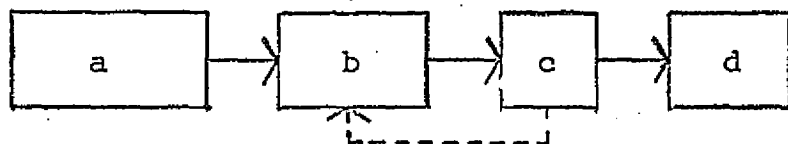
3) A likely application of geographic information system approaches, particularly systematic correlation of multiple inputs, including remotely-sensed land classification data, is used

# DIAGRAM

# DESCRIPTION

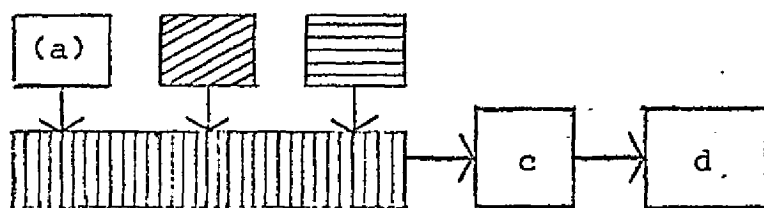
# COMMENTS

0)



0) Baseline.

4)

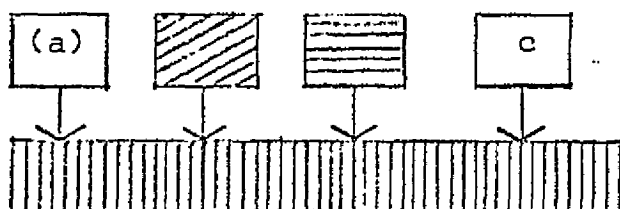


4) Step-backwater analysis eliminated -- rate map directly from cross-sections and improved flood boundary delineation. Possible reduction or elimination of cross-section survey requirements.

4) A fundamental conceptual alteration of Flood Study methods. Implies use of remote land classification inputs for floodplain delineation; and a new analytical method.

110

5)



5) Combination of 4 and 5: integrative use of geographic information system techniques from start to finish.

5) A refinement of #4 that would result in a comprehensive new approach to Flood Insurance Studies.

APPENDIX 5.2.4  
POTENTIAL DEMONSTRATION TASKS  
FOR  
FEDERAL FLOOD INSURANCE STUDIES

23 Jan 76

I. Introduction and Background

Federal legislation passed in 1973 produced a framework wherein communities could apply for flood insurance underwritten by the federal government. The Federal Insurance Administration (FIA) of the U.S. Department of Housing and Urban Development (HUD) is currently contracting for flood insurance studies in U.S. communities. Preliminary studies for all 21,000 communities and the 3,000 counties in the U.S. are being studied by approximate methods to delimit the regions within the 1 in 100 year floodway. A detailed flood insurance study is being produced for each community entering the insurance program to delimit the flood hazard boundary in detail (on 1:12000 scale maps) and also produce a flood insurance rate map. The sheer number of studies required, as well as the time constraints imposed on completion of the flood insurance study program, have created interest on FIA's part to investigate other techniques to pursue these studies in a more cost-effective manner.

In addition to the preliminary and detailed Flood Insurance Studies being addressed, FIA recognizes four additional types of studies that need to be undertaken to fulfill the overall program's charter: First, tidal flooding, as opposed to riverine flooding, is an aspect of flood insurance studies which need to be addressed in a more expeditious manner than the presently used NOAA computer programs. Second, the delineation of regions subject to erosion, mudflow, and landslide hazards are of concern to FIA, but they are not as important or tractable as riverine flooding studies. Third, FIA needs to systematically address the effects of urbanization and development on runoff, topography, and floodways. Fourth, FIA will have to address the problem of compliance, i.e., seeing that development patterns are in fact responsive to known flood hazards. Since 22,000 communities in all 3000 U.S. counties need to be monitored, approaches other than ground-based inspection procedures need to be assessed.

On December 5, 1975, a meeting on the subject of Flood Insurance Studies was attended by NASA, USGS, and HUD representatives. NASA representatives were there acquainted with FIA procedures and USGS and FIA representatives were informed of potential NASA technology that could be applied to improve flood insurance study techniques and procedures.

II. Approaches

A report of the December 5, 1975 meeting at HUD and analyses of the FIA procedures made by Technology and Economics Inc. has pointed out several areas where NASA/JPL may be able to provide technical assistance. Of the possibilities mentioned, six would, at this time, appear to be approachable on a demonstration basis:

- A. JPL, in cooperation with Goddard Space Flight Center, could demonstrate the suitability of using LANDSAT imagery to derive preliminary floodplain delineation studies for the remaining 3000 county regions requiring these maps. It should be possible for JPL to rapidly generate floodplain delineation maps for the Las Vegas, Nevada and Fox-Chain-of-Lakes, Illinois, regions. Upon completion of the task, should accuracy and feasibility be demonstrated, JPL would, by a mutually agreed upon date provide FIA with hardware and software specifications to undertake the remainder of the preliminary studies.

- B. JPL could extend its present urban change detection study to demonstrate the capability of LANDSAT to monitor urban development in a region where a floodway has been defined. Houston, Texas would be a good test area for a demonstration project, as it is an area undergoing rapid urban development, has a completed preliminary flood insurance map, and is an ongoing JPL research site. Urban development would be monitored from LANDSAT images taken at one year intervals from 1972 through 1976.
- C. An extension of the Houston project proposed in B would incorporate the generation of thematic images of impervious surface area within the floodway and the interfacing of the data with models of surface runoff to assess the impact of urban development upon flood frequency probabilities.
- D. JPL could investigate the design requirements and potential for an airborne cross-flight scanning laser altimeter to accurately measure stream floodplain profiles. Such a system should provide valid data for the majority of flood-prone rivers and streams that have restricted channels but broad floodplains. Should feasibility be proven, JPL could construct and flight-test a prototype model and provide FIA with instrumentation specifications.
- E. An extension of ongoing digital image processing techniques should permit the development of a software and hardware system, capable of automatically ~~computing~~ <sup>computing</sup> generating stream floodplain profiles. It should accept a variety of input devices, including that proposed in D, and generate an output data set that can interface to existing step-backwater floodway models. The system would be designed to be a transportable stand-alone system.
- F. A further development of existing computer algorithms applied to solid state random access mass-memory devices should permit JPL to efficiently and rapidly generate the detailed flood insurance study floodway contours for 1-in-10, -25, -50, -100, -500-year floods. The system would be transportable.

### III. JPL Tasks

An attempt has been made to separate those tasks JPL feels confident in attempting into discrete modules which FIA/HUD can choose on a case by case basis and initiate at any time convenient to HUD. Thus, it would be possible to initiate all six demonstrations at the same time, or stage their initiation in accordance with FIA funding and time constraints. Listed below are approximate costs and times to perform the tasks outlined:

- A. Preliminary Floodplain delineation from LANDSAT. Three months to demonstrate. JPL Funding ~~\$10K.~~ \$25K.
- B. Floodway Urban Development Monitoring. Six months to demonstrate. JPL funding \$40K.
- C. Modelling impact of urbanization upon stormwater runoff. Three months to demonstrate after completion of B. JPL funding \$25K.

- D. Airborne cross-flight scanning laser altimeter. Six months to assess feasibility and applicability. Funding required for this phase \$50K. One additional year to construct and flight test a prototype model. Funding required for this phase \$250K.
- E. System to automatically generate cross stream profiles for input to step-backwater floodway computer models. 18 months to develop a prototype system. Funding \$100K.
- F. Demonstrate the application of image based information system techniques to generate floodway and insurance rate contours. 18 months to develop a prototype system. Funding \$100K.